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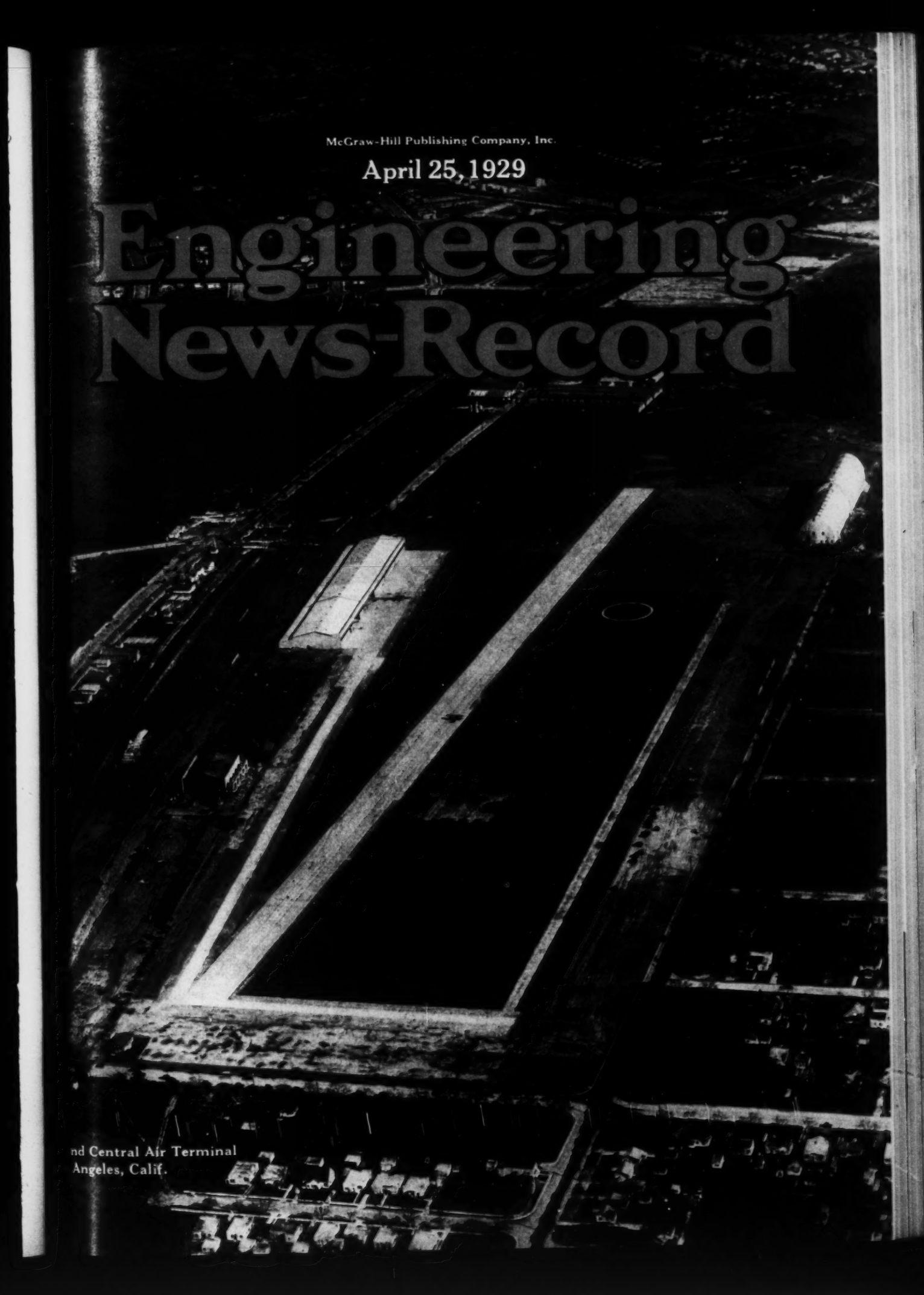
Engineering News-Record



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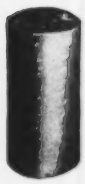
Compressive Strengths

at number of days indicated

At 3 days
3086
lb. per sq. in.
(*average*)

At 7 days
3997
lb. per sq. in.
(*average*)

At 28 days
4882
lb. per sq. in.
(*average*)



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Volume 102 NEW YORK, APRIL 25, 1929 Number 17

Great Earth Dams

WITH a volume of eleven million yards, a crest length of one and a half miles, a base width of 1,150 ft. and a height of 208 ft., the Saluda dam surpasses in magnitude nearly all previous structures of its type; it is second only to the Gatun dam in Panama, which contains nearly twice its volume but is only 120 ft. high. However, an observer standing on the hill overlooking the Saluda River and the construction operations stretching across the valley to the other side a mile and a half distant is impressed with more than the size of the project. He feels a professional respect for those who visioned the possibilities of a hydro-electric project of this magnitude to be developed on a small stream in a wide valley among comparatively low hills. Yet the site is peculiarly well adapted for such a development. The fifteen years' time since the completion of Gatun has increased our knowledge of earth dams, and though we still have much to learn of their best design and construction, the position of earth dams as safe and serviceable structures has been greatly strengthened. Not only are they the oldest dams of human creation, but they hold a strong claim to being the best structures of their type. Such works as Gatun and Saluda foreshadow that many great earth dams will be counted among the works of the future.

By Rail and Water

ACTING under a mandate from Congress, the Interstate Commerce Commission has issued a general order requiring the establishment of joint through rail-and-water rates on all railroads connecting with the government-owned barge lines on the Mississippi and Warrior rivers. The Inland Waterways Corporation, which operates the barge lines, has been fighting for the establishment of such rates for a long time but has in the past failed to get more than a few established. Now any shipper may route his goods by barge for part of their journey and obtain a reduction over the all-rail rate where the barge-line routing is not more than 40 per cent longer than the all-rail route. Congress wants to see the barge lines part of the transportation system of the country. The railroads, particularly those which parallel the barge lines, have opposed the establishment of joint rates just as they have opposed the establishment of barge lines, and consequently an order such as the Interstate Commerce Commission has now issued was necessary before the Inland Waterways Corporation could show definitely whether or not the barge lines can be made an effective part of our transportation system. So far, they have been an expensive experiment. It is now up to the corporation to show that even despite the double handling charge where a rail-barge-rail movement is involved the barge lines can show an advantage to the shipper. It may also be that the competitive rates established by the railroads to keep traffic from the barge lines will now rise up to plague them under the new through rates.

Interstate Waters Again

UNTIL recent years the West was the center of gravity of interstate water controversies, but events are tending to shift that center toward the East. New York City's project for a water supply from the headwaters of the Delaware, opposed by New Jersey and Pennsylvania, is the latest case, though in its essentials it is very similar to the dispute between Connecticut and Massachusetts over the plan to supply Boston from certain tributaries of the Connecticut River. In both instances the streams to be impounded lie wholly within the taking states, and the downstream opposition rests on the claim of impaired navigability by lowered water level, although at least in the New York case any influence on navigation is precluded by provision for maintenance of dry-season flow at the impounding dams. The proceedings in both cases are of exceptional importance because they give opportunity for a fundamental interpretation by the U. S. Supreme Court of rights in interstate waters under the riparian rights system of law. With one exception, all important cases heretofore have concerned Western conditions, where the appropriation law controls, and therefore do not bear on Eastern cases. The exception is the Chicago lake diversion suit, recently decided by the Supreme Court; but, despite the basic importance of this decision, it is not a direct precedent, because affected by other considerations, including the extent of the War Department's authority, which many engineers suspect has been stretched beyond the scope of its Congressional warrant. A large amount of future progress depends on the outcome of the Massachusetts and New York cases, since river waters are coming into much more extensive utilization and practically all streams traverse or touch more than one state before reaching the sea. It is therefore to be hoped that decisions will be rendered which shall lay a firm foundation for ready determination of mutual rights and obligations of riparian owners.

The Flood Question

NOT only navigation but also high-water stages are involved in the problem of interstate waters, since headwater storage reduces flood flow. Floods are active hazards on all streams, and therefore the influence of impounding reservoirs is bound to be beneficial. But there is on the judicial records the unique finding of the California courts in the Herminghaus case, where it was held that the downstream riparian owner (California law being based mainly on the riparian doctrine) has a right of ownership in high-water stages, even the stages of

harmful floods. Comment on this curious piece of jurisprudence will be found in *Engineering News-Record*, Feb. 3, 1927, page 181. While no interstate water question was here involved and the decision will therefore probably not serve as precedent in the current Eastern cases, nevertheless it is desirable that these cases be argued on the score of flood conditions as well as low-water conditions, in order that the specter of flood-stage rights may not have a chance to rise. The increasing gravity of flood problems everywhere in the nation is sure to bring about extensive flood-control work during the next few decades, and this work should not be checked or complicated by legal uncertainties, above all by those which would arise from any lack of clearness as to state rights in joint waters.

Public Safety First

REGARDLESS of the cause of the accident, there is no excuse for the loss of life last Saturday when a steel erection derrick dropped its load of beams from the twentieth floor of a new building in New York. Two workmen were hurled to death from a scaffold on the eighth floor, two others were killed standing on the sidewalk, at a spot passed by hundreds of pedestrians daily. At this writing there has been no satisfactory explanation of what caused a 15-ton derrick to drop a 3½-ton load. But regardless of explanations it should be repeated that hoisting steel over the heads of workmen, pedestrians and traffic is a hazardous procedure. There is no imperative need for such practice. Derrick failures have happened with startling frequency, and evidently they will keep on happening despite the apparent possibilities of accurately calculating all stresses. Therefore it is pure disregard of public safety to permit human life to be endangered by the ever-constant possibility of a derrick failure. Despite our present-day rush to get from here to there, is it not safer to hold back pedestrians and street traffic for a few moments while a heavy load of steel is being hoisted skyward than to take a chance of a tragedy? No contractor would hesitate to take all safety precautions possible if he were using dynamite in a crowded street. Yet a load of girders dangling above a crowded street is just as dangerous. It is time that building contractors themselves took the lead in steps to eliminate this hazard. Should a derrick or load of steel crash down from a height into a crowd of pedestrians or into a street filled with traffic, the tragedy would be a shameful blot on the entire contracting profession. It must not happen.

A Construction Advance

STRENGTHENING concrete building columns and girders to take heavier load, as when stories are to be added to an existing structure, is structurally uncertain and invariably a pestiferous task for the constructor. Further, unit costs are sure to run so high that the owner has all the sensations of falling among footpads. Yet the constructor perhaps profits as little as from any work which he undertakes. The reason is apparent if study is made of the concrete building strengthening operation described in this issue. Enlarging the section of a column is not merely adding a shell of concrete and reinforcement but requires that the shell shall be incorporated into a monolithic unit with the original core of concrete and steel. Anyone who has had the task of grafting new concrete to old concrete knows the difficulty of making the two integral. He is rarely successful except by chance when he works with concrete poured and rodded into forms built around the core member to be enlarged. To overcome this major difficulty in the work described, gunite was substituted for poured concrete. It did not lessen the necessity of breaking away the old column surface so as to expose its steel skeleton and of binding the shell steel rigidly to the core steel, but when these were accomplished, it gave the certainty of visible work in placing by a process that has proved highly reliable. It makes the strengthening of a concrete column comparable to the work of strengthening a steel column.

Mississippi Levee Construction

A BRIEF for the cableway excavator as a levee-building machine on the Mississippi is presented in this issue by an engineer of long experience on the river work. His argument that the machine has not come to its limits in reach for borrow material needs no extension. It is of more importance to review his conviction, first, that any considerable effort to select materials for levees is not warranted by prospective gain in levee stability, and second, that going far afield for borrow will not commonly be necessary.

Quantitative proof or disproof of either claim is difficult without considerably more complete knowledge than is now available of where the new work will be and what choice of material is practicable in any particular location. As between sand, silt or loam and buckshot clay the differences in levee section commonly required are indicative of different values. In the sections tabulated in the article there is at least a saving in yardage where buckshot is available—briefly, 1,200 cu.yd. every 100 ft. as compared with loam and nearly 5,000 cu.yd. as compared with sand. Merely on the basis of volume to be handled the clay is worth going some distance to secure.

The crucial question is, of course, whether any two or all three materials exist in any locality within economic distances of the levee. In some locations they do not. Here lies the point of contention that many engineers have with the present and older practices of Mississippi levee work. They deny, because levees have always been built by dumping in mass the nearest material to be had, that this way need be continued. They are doubtful, too, whether always the material closest at hand in any locality is as good as any other material or combination of materials which the locality affords. They doubt whether any particular search has commonly been made to disclose the material resources of any locality for the purpose of developing the most economic stable embankment material. In short, they are not convinced that construction engineering study is at its end in Mississippi levee structure and construction. They are much less convinced that levee building has any common denominator of plant and processes which applies from Cairo to New Orleans. Rather it seems clear that virtually every levee operation calls for a different divisor.

This leads directly to the question whether in the new levee work there must be commonly any excursion afield for borrow material. The answer is that it is invariably a local problem; in new levees there will be ample borrow of a kind everywhere adjacent, in enlargement work sometimes an extension of the old pits will serve, and sometimes the fill must be brought from beyond. Again the problem is one to be solved from the facts without prejudice by old practices. The argument here is in brief the argument respecting selection of embankment material: Avoid the conclusion that there is anything def-

initive about the practices of the past in Mississippi levee construction engineering.

It has been a point of censure in the present plan for flood protection in the great valley that planning has preceded engineering study. The construction industry should not permit a similar error by tacitly accepting the adequacy of traditional construction practices. The machines of today have their place; the single-unit levee-building plant has its very important place; the dumped-fill levee of the nearest material has shown efficiency. But at present it is in order to study other levee structure, to seek multiple-unit plant combinations, and to improve old machines. Let engineers see that the task is encouraged.

New Factors in Technical Progress

IT IS a satisfaction to observe that industrial associations are contributing in increasing degree to the available stock of technical knowledge. Research as well as the compilation of authoritative existing knowledge has been taken up by these organizations as leading elements of their work. During their steady development throughout the past decade, industrial associations have evidently learned to appreciate that such service is among their chief obligations and that in their own interest it is incumbent upon them to set forth fully and authoritatively the technical possibilities of their respective arts.

Several recent publications give evidence of the trend of industrial association activities toward this technical cultivation of their field. To cite only a few: A handbook on steel structural elements was issued by the fabricators' association, a little manual on brick engineering was published by the brick manufacturers, and a voluminous collection of references and abstracts on blast-furnace slag is being issued serially by the slag producers. Such work clearly reflects a constructive attitude toward the relations between the industry and its clients.

This is significant progress from that earlier period when industrial associations were thought of primarily as tools of competitive commercial warfare. In a few fields the old idea still survives in traces, but it is thoroughly out of tune with the spirit and demands of technological industry today. There is now a wide understanding of the fact that an industrial association may concern itself with the affairs of its industry alone, not with those of competing industries. Its essential function is to show how its own products can be made and used more efficiently; comparison and selection are the problem of the user.

Broadly, the service of the industrial association is of two kinds: improvement of defective conditions within its own industry, by dealing with matters of internal competition or of joint interest that cannot be dealt with effectively by the individual producer; and technical development of the product, including circulation of knowledge of the product. In the former field are such things as bad commercial practices, problems of marketing, and traffic matters; in the latter, research on the one hand, and compilation and publication of data on the other.

Much remains to be done before all industrial association activity is focused on these objectives in a purposeful way. Yet, since development is steadily trending in that direction, the outlook is that industrial associations will exert an increasingly constructive influence on both technology and business.

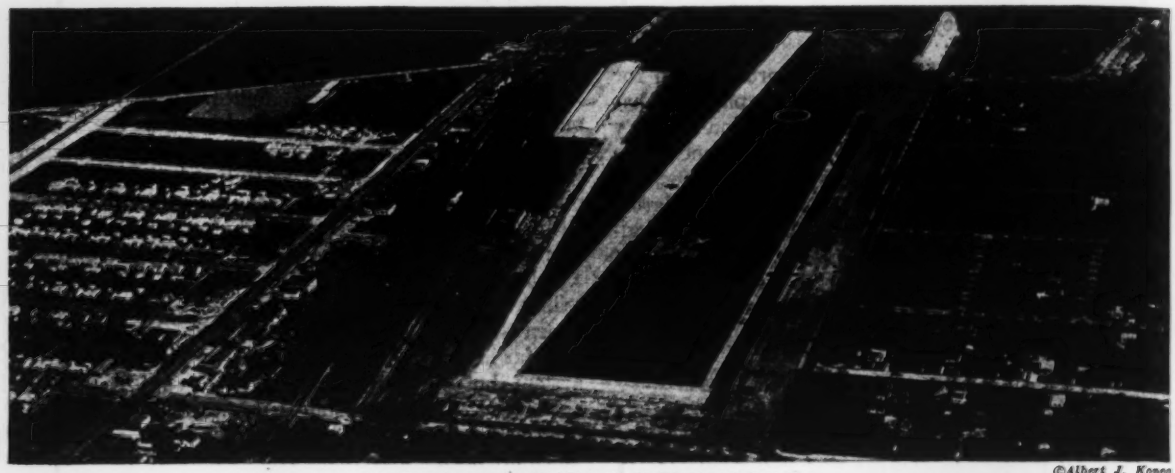
Competition or Duplication

THE Pacific slope west of the Sierra Nevada is divided roughly in half by a mountain barrier running diagonally across northern California, known as the Siskiyou Range. To the south are the broad valleys of California, which have a tremendous agricultural output, and the metropolitan areas of San Francisco and Los Angeles, with their rapidly increasing industrial development. North of the barrier is the Pacific Northwest, including Portland, Seattle and Tacoma and the productive areas tributary to these centers. Railroad transportation between these two major divisions of the West Coast has thus far been provided exclusively by the Southern Pacific system, but the right to this exclusive privilege is now challenged. The Interstate Commerce Commission has been asked to decide whether the facilities as now provided are adequate so that a continuation of the monopoly should be approved, or whether public convenience and necessity require the stimulus of competition. In other words, the Great Northern and Western Pacific railways, whose systems at present approach within 200 miles of a juncture across this California mountain barrier, are asking permission to connect their lines, thereby providing a second route between the two major divisions of the West Coast territory.

The future of Pacific Coast development depends on adequate transportation. Whether this can be better and more cheaply provided by developing the existing single carrier or by allowing competing routes is the question at issue. Naturally the existing utility, having so long enjoyed its monopoly, will protest, will fight to establish the adequacy of the present facilities and, pleading that maintaining adequate rail service has been the chief factor in developing the territory, will demand protection for the investment. The opposition no doubt will point out that provision of adequate facilities implies no special merit, since it is an obligation which the utility owes the public in return for the privilege of monopoly. To keep a public service ahead of actual requirements is merely good business practice in forestalling an insistent demand for competition.

The question of tributary traffic along the new mileage to be built is not of particular importance, but a second through route to the Pacific Northwest would be a great stimulus to the development of new territory. It has, moreover, a distinct economic and military significance, inasmuch as the existing route for a distance of more than 100 miles in the canyon of the Sacramento River is only a single-track line. All freight and passenger traffic both ways has to be squeezed through this bottleneck. When landslides, wrecks, tunnel fires or other interruptions have occurred on this single track, the entire north and south system has been paralyzed and all traffic has stopped. Detours around the blockade over other lines are impracticable, for that would mean traversing more than double the direct rail mileage between San Francisco and Portland.

The questions at issue are vital to the entire Pacific Coast; they involve the possible advantages of competition and of alternative routes as compared with the possible disadvantages of unnecessarily duplicating service with the attendant increased burden on the ultimate consumer. The duplication costs can readily be reduced to dollars and cents; what the result of competition would be is a matter in which good judgment is needed, and having been placed before the Interstate Commerce Commission the case is in excellent hands.



AIRVIEW OF PARTLY COMPLETED AIRPORT
Only one runway completed. The landing strip parallels the runway and extends through circle.

©Albert J. Kopec

Constructing a Dustless Landing Strip for Air Terminal at Los Angeles

Grand Central Air Terminal, Los Angeles, Has 6-In. Oil-Impregnated Surface Layer Over a 300x1,500-Ft. Area—Concrete Runways—Dust Abatement for Entire Airport

THE Grand Central Air Terminal recently opened for public use at Glendale, Calif., a suburb of Los Angeles, is equipped with concrete runways, has hangars of fireproof construction and when the proposed extensions are completed will qualify for an A1A Department of Commerce rating. The feature of greatest interest is the success of the dust-abatement methods, particularly in the 300x1,500-ft. landing strip, where a 6-in. depth of firm but resilient surfacing has been waterproofed and rendered dustless at a cost of about 7c. per square foot.

The site was chosen because it is only fifteen minutes by automobile from the Los Angeles City Hall and is situated in a wide, sheltered valley where the winds are reported to blow in an up-valley direction 90 per cent of the time. Because most of the takeoffs will therefore be made in one direction, the runway was located accordingly and was built of concrete 72 ft. wide and 3,000 ft. long, with provision for ultimate extension to 4,000 ft. The total runway width was brought up to 92 ft. by adding 10 ft. of 3-in. asphaltic paving on either side of the concrete.

The concrete is 6 in. thick at the edges and 5 in. at the center; it consists of a 1:2½:3½ mix, without reinforcing; has dummy transverse joints every 33 ft. and full expansion joints 100 ft. apart. The paving was laid in three 24-ft. strips poured alternately.

In addition to this main runway and connecting with its north end there is a concrete paved taxi strip extending along the east side of the airport, leading directly in front of the passenger terminal and widening out to a warming-up floor in front of the hangars beyond. The width of the taxi strip from hangars to runway is extended by a 20-ft. width of 3-in. asphaltic concrete on either side. Twenty-foot taxi strips of 3-in. asphaltic concrete are laid on the north and west sides of the field.

The hangars are of all-fireproof construction with 100-ft. steel roof trusses so that there are no columns in the entire inclosed area. Up to April 1 a total of 940 lin.ft. of hangars 130 ft. wide (this width including offices along the side away from the field) had been completed or was under way. The Transcontinental Air Transport Company has leased 31,200 sq.ft. of space for hangars; other leases include the Maddux Air Lines, with 52,000 sq.ft., the Pickwick Airways, with 26,000 sq.ft., and a number of smaller operators.

Ultimately housing facilities can be extended entirely around the field if necessary. In order to conform to the requirements of the Department of Commerce for two takeoff runways intersecting at an angle of not

DISK HARROWING WAS ALTERNATED WITH OIL APPLICATION
Disks cutting 6 to 7 in. deep worked over the surface after each application.

less than 60 deg., construction is to begin in the near future on the second concrete runway, which will be 3,500 ft. long.

The ground at the site had a general slope of about 6 in. per 100 ft. toward the Los Angeles River, and when construction of the airport was begun the first operation was to work over the surface with fresnos until all low spots had been filled in and a smooth, uniform slope was secured so that surface water would run off readily.

For dust abatement over the field generally, a single application of a special grade of road oil having 60 to 70 per cent asphalt content was made under pressure and with oil at a temperature of 120 deg. F. About ½ gal. per square yard was applied in this way, securing an average penetration of ½ to 1 in. Before making the oil application it was found important to have the surface smooth and well compacted on a uniform grade.

Approximately 167,000 sq.yd. treated in this way has been found to remain dustless. Where disturbance of the surface is caused by out-of-place landings or by high-speed taxi-ing, occasional light maintenance is required. It is expected that the entire area may require a repetition of this penetration oiling after a period of service of perhaps six months to a year, according to the amount of rough usage.

SPECIFICATIONS FOR SAND USED IN LANDING STRIP

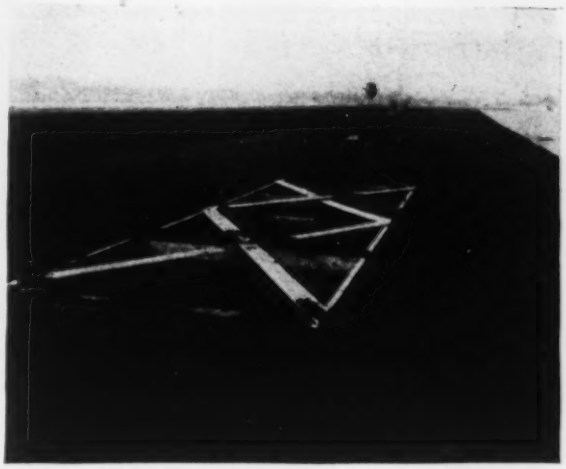
Sieves	Per Cent	Sieves	Per Cent
200	0 to 5	30	8 to 16
100	0 to 5	20	15 to 30
80	0 to 5	10	15 to 30
50	5 to 15	¼	15 to 30
40	5 to 15		

RESULTS OF EXAMINATION OF THE UNTREATED SURFACE SOIL

Sieve Analysis	Per Cent
Passing 200 mesh	33.0
Passing 100 mesh and retained on 200 mesh	19.5
Passing 80 mesh and retained on 100 mesh	8.5
Passing 50 mesh and retained on 80 mesh	11.1
Passing 40 mesh and retained on 50 mesh	9.2
Passing 30 mesh and retained on 40 mesh	6.6
Passing 20 mesh and retained on 30 mesh	5.8
Passing 10 mesh and retained on 20 mesh	4.1
Passing ¼-in. ring and retained on 10 mesh	2.2
Total soil	100.0

Separation and Classification:	Per Cent
Clay	7.6
Silt	25.4
Sand	64.8
Rock	2.2
Total soil	100.0

Determination of Sulphates:	Per Cent
Calcium sulphate ($CaSO_4$)	0.001
Sodium sulphate (Na_2SO_4)	absent



LIGHT DRAG USED FOR SMOOTHING OFF

This operation followed by one trip of a light roller finished landing strip ready for service.

In contrast to this light oil application for dust abatement, the landing strip, which parallels the concrete runway, was prepared with much more elaboate treatment to secure an area that would not be damaged even by the roughest landings. In this area the objective was to get a firm but resilient waterproof layer of soil 6 in. thick. This depth is more than tail skids can penetrate; therefore rough usage will not make openings through which water can reach the subgrade.

A soil analysis showed the surface material to be an admixture of silt and sand of a very fine-grained texture. In fact, it was so fine that to have applied oil without first working in coarser material would have resulted in a thin crust of soil and oil which would not last long because of the high percentage of silt and the absorbent quality of the very fine particles which are said to shorten the effective life of oil. This is just the opposite effect to that produced by admixture of oil and sand; the individual sand grains do not absorb oil, but instead are said to support and preserve its natural qualities.

SUCCESSIVE STAGES IN BLADING OPERATIONS

Dark strip at right contains no more oil than does foreground, but has been worked more.

A WELL-MIXED PORTION OF LANDING STRIP
Windrow in foreground built up by repeated turning over with blader.

Laboratory experiments were made with various quantities of sand in combination with samples of the silt, all based on the objective of a 6-in. layer of the admixed materials. A 3-in. layer of sand, worked up with silt to give a 6-in. layer, resulted in a mixture such that 4 gal. of oil per square yard was required to produce the plastic qualities desired. The maximum of efficiency and economy was found with a 4-in. depth of sand, to which was added enough silt to bring the layer to a 6-in. thickness. This combination required only 3.2 gal. of oil per square yard to give the desired consistency.

Based on this determination, enough coarse, washed sand was dumped on the 300x1,500-ft. landing strip, so that when spread by fresnos and smoothed off with a light drag it gave a uniform sand layer 4 in. deep. The entire area was then disked to a depth of 6 or 7 in., thus making furrows in the sand and cutting 2 to 3 in. into the silt. Finally the light drag was used over the entire area once more and the job was ready for oil.

The oil used on the landing strip was a steam-distilled product of 60 to 70 per cent asphalt content, the 80 penetration residuum of which was not more than 80 per cent soluble in petroleum ether. The oil was applied from pressure trucks at temperatures of 300 deg. F. The oil was put on in five or six applications and the entire area was disked after each application. It was found that the maximum amount of oil that could be absorbed to good advantage in each application was about $\frac{3}{4}$ gal. per square yard.

The full amount of oil prescribed was put on with only the disk harrowing between successive applications (no drags being used in this operation), and after oil applications had been completed the surface was worked repeatedly with road graders so as thoroughly to mix the oil with the sand and silt. These graders had 12-ft. blades. Three or four of them were used almost continuously, and it was found that 40 to 50 trips were required over every part of the surface to secure the desired admixture.

The bladers worked the full 1,500-ft. length in 25-ft. strips. The material was first scraped to one side of the 25-ft. strip, where it was piled in a windrow, and then a series of successive trips moved it back to a windrow on the opposite side of the strip. This blading from one side to the other was repeated until the oiled material was uniformly black, indicating evenly distributed oil.

After the graders had finished, the area was smoothed off to a uniform 6-in. thickness by the use of light 8x24-ft. timber drags drawn by 2-ton tractors. Great care was taken in this dragging to get the slope uniform. As a final operation an 8-ton tandem roller went over the entire area once, thus giving a finished surface not too solidly compacted. Tests were made with a 12-ton roller, but this weight produced an undesirable solidity of the oiled material.

Due to the necessity for completing the landing strip prior to the date that had been announced for the airport opening, enough equipment was concentrated on the job so that the entire oiling and working of the 300x1,500-ft. area was completed in twelve days. The cost of the labor and materials used in the landing strip as estimated on the basis of laboratory tests was to be as follows:

	Per Sq.Ft.
Four-inch sand layer	$0.013
Special oil at 3.2 gal. per square yard	0.028
Mixing and finishing	0.005
Total	$0.046

This estimate was low, however, and the total costs when the work was finished amounted to about 7c. per square foot.

Charles A. Lindbergh, as consultant for one of the air transport companies that have leased space at this terminal, has pronounced the landing strip the finest of its kind he has seen. It yields readily, thus decreasing rebound in rough landings, and its depth and structure insure permanent watertightness. The 0.5 per cent slope is sufficient to carry off the surface water rapidly enough to prevent emulsification of the oil and, finally, there is no dust to be stirred up by landings and takeoffs. The company that supplied the oil has guaranteed the area against dust for a period of one year.

The Grand Central Air Terminal was financed and developed by C. C. Spicer and C. A. Spicer, of Los Angeles. The latter is a member of the Associated General Contractors and had charge of all construction as general contractor. L. D. Fish, research engineer for the Gilmore Oil Company, prescribed the grades of oil to be used and co-operated with C. A. Spicer in developing the methods of constructing the landing strip.

APPLYING OIL AFTER SURFACE HAD BEEN PREPARED
Four applications, each of about 0.8 gal. per square yard, were made.

Strengthening Weak Building Columns by Gunite Enlargement

Additional Section Tied Into and Bonded With Old Section—Methods and Plant Described, With General Cost Figures

By Howard D. Hilborn
Structural Engineer, Miami, Fla.

TO REPAIR weakness in the original design of a reinforced-concrete hotel building being constructed at Miami, Fla., in 1927, 29 columns and 53 beams well distributed over the building had to be reinforced. From a study of the conditions it was apparent that the necessary work could be most quickly and cheaply done by means of a cement gun. After the weak beams and columns had been listed, plans were studied at the building—each member being examined with regard to the obstacles surrounding it—and an effort was made to avoid as far as practicable the removal of masonry walls or partitions already in place.

General Construction Plan—Beams coming in the spandrel walls, in stair or elevator shafts or in locations over and under partitions where additions could not be readily made to the top or bottom faces were built out on the side only. In general where a choice presented itself it was preferred to build up the beam on top, deepening it sufficiently to provide the requisite effective *a* for the existing steel. In still other cases the existing reinforcing steel was so utterly inadequate that it was considered advisable to deepen the beam to satisfy compression and shear requirements, adding the necessary tension bars at a lower level. Regardless of where the reinforcement was placed, the new steel was tied to the existing rods as illustrated in the sections, Fig. 1.

In determining the additional section required, the

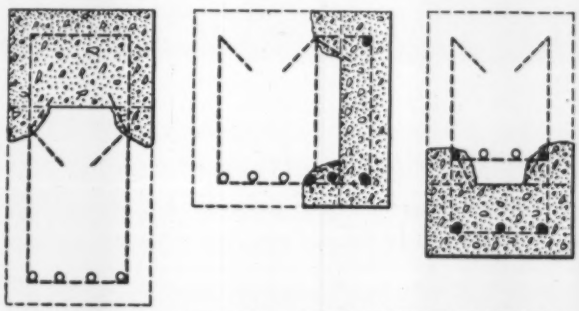


FIG. 1—TYPICAL METHODS OF BEAM STRENGTHENING

existing concrete, a good quality of 1:2:4 poured concrete, was stressed to 650 lb. per sq.in. in flexure and the gunite to 1,200 lb. Shearing and bond stresses were in the same ratio.

Columns located in walls were built out on one side only or on the full exposed perimeter, depending on the excess load to be carried. Interior columns were completely incased. The sections in Fig. 2 show details. Concrete in the original column sections was stressed to 450 lb. per sq.in. and *n* was taken as 15. On the cement gun additions stresses were 900 lb. per sq.in. on the gunite with *n* taken as 10. The minimum section necessary for protection of the steel was in this case held down to 1½ in. by recessing the new steel into the faces of the existing concrete.

Guniting Methods—A gunite mixture of 1:2½ was specified. As the loss of sand due to rebound amounted to approximately 20 per cent, it was decided to mix the dry cement and sand in the proportion of one to three. The moisture content of the sand was held down to from 5 to 10 per cent.

In preparation for placing reinforcing on beams or columns, sufficient concrete was first cut away with an air chipping hammer to permit of hooking the new beam stirrups or column ties behind the existing steel. This was not necessary in the case of columns to be completely incased. Before placing reinforcing rods in position, surfaces on which gunite was to be placed were roughened slightly to insure bonding. After the reinforcing had been secured in place and just prior to shooting on the gunite the surfaces were cleaned from dust and loose concrete particles by means of the air line. The old

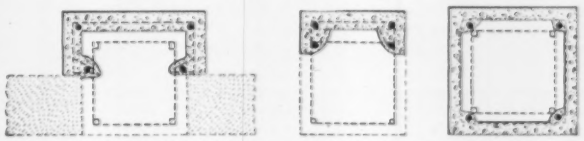


FIG. 2—TYPES OF GUNITE COLUMN ENLARGEMENT

concrete was drenched with water applied under pressure from the water line. Very little formwork was necessary; shooting strips were used.

The equipment required for the gunite work included one gun and two portable air compressors having a capacity of 310 cu.ft. each at 80-lb. pressure. Some 200 ft. of hose was in use at one time, enabling the contractor to keep his plant stationary. The plant remained on the ground level while guniting beams on the third floor and observation platform levels. Two pneumatic chipping hammers were used in preparing the surfaces and uncovering the existing reinforcing.

Quantities and Costs—A total of 446 cu.ft. of gunite was placed under a sub-contract on the basis of a fixed daily charge of $95. This amount covered the rental on the cement gun and one air compressor as well as the services of a crew of three men. The work was completed in eighteen days. In addition to the $1,710 paid to the sub-contractor, the general contractor's expense in connection with the strengthening of the frame included $64 rental on equipment not furnished by the sub-contractor, 494 sacks of cement, 4,100 lb. of reinforcing steel, 62 cu.yd. of sand, 4,200 ft. b.m. of lumber, a payroll cost of $1,905 and miscellaneous items amounting to $160. The total cost of the repairs was $4,686 exclusive of engineering. Based on the quantities of material placed, this cost appears high, but it was the cheapest and quickest method of making the necessary alterations.

The St. John Construction Company, of Miami, Fla., was general contractor on the original building and also on the revision. On the work of reinforcing the frame the general contractor did the necessary chipping, forming and placing of reinforcing steel. The gunite work proper was sub-contracted to G. O. Reed, Inc., of Miami Beach, Fla. The writer made the design for the revision and supervised the work.

Flood Damage to Tennessee Roads

Damage to the highway systems in the eastern and central sections of Tennessee from the recent floods in that state will reach approximately $500,000, according to reports to the state highway department.

Air-Rights Office Building in Chicago

Tall Steel Frame Structure Over Union Station Tracks—Newspaper Occupies Lower Floors—Ventilation of Track Space—Trusses and Cantilever Girders

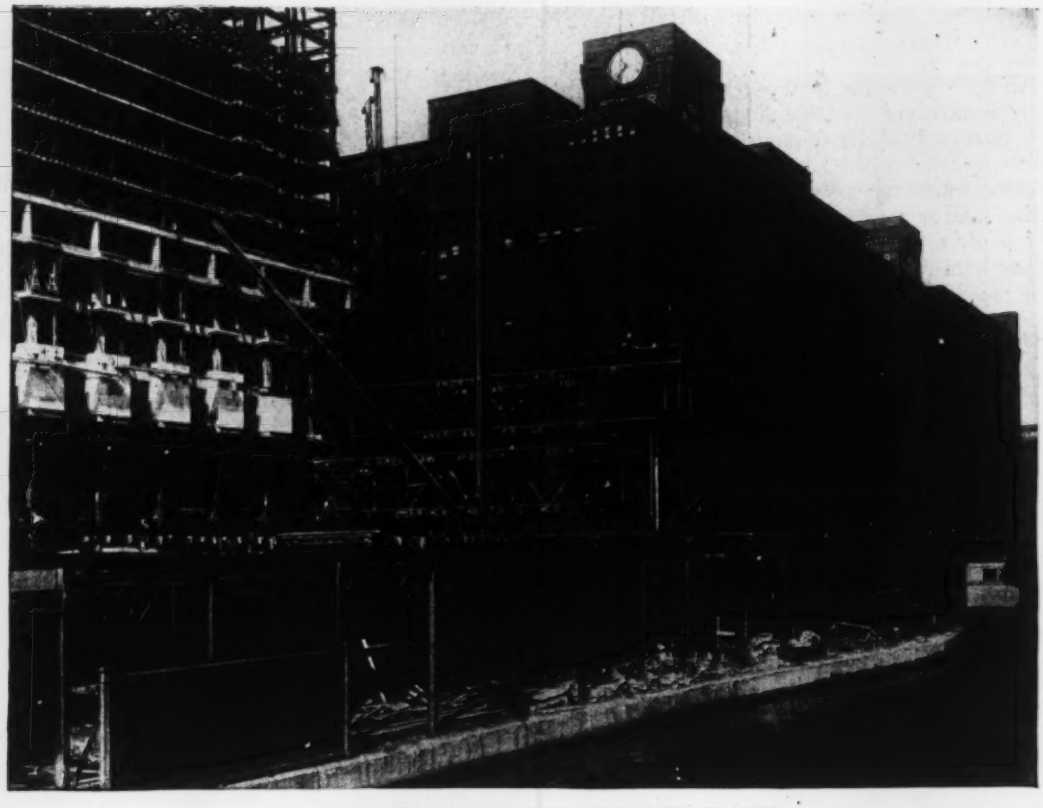


FIG. 1—TRUSSES CARRY BUILDING OVER TRACKS
Main part of Daily News Building at left. Trusses in north wing have hangers carrying floors over Union Station tracks. Washington St. bridge at right.

AS CHICAGO'S first large air-rights office building, erected over railroad tracks and right-of-way, the Daily News Building, now under construction across the north approach to the Union Station, is of rather particular interest, and its design includes a number of unusual features. While only a corner of the main structure extends over the track space, requiring special structural features, the two four-story wings extend entirely across this space and require trusses, cantilever girders and hangers for their support. These parts of the building are located over the fan-shaped layout of tracks connecting the platform tracks with the main-line approach, so that no two tracks are parallel and numerous turnouts and crossovers are included.

These conditions governed the column locations below the main floor, and the framing had to be designed to fit these locations. At one point, where an upper-story truss had to be placed, it was not possible to place a column to carry its outer end; therefore this end is supported on a heavy A-frame, carried by two neighboring columns. In Fig. 1 are shown some of the trusses, hangers from which carry floors over the tracks occupying the space back of the river wall. At the right is the bridge carrying Washington St. across the tracks, with the masonry pier for the bascule span across the river. The track layout and column locations are shown in Fig. 2.

This large building fronts on the east side of Canal St., on which side are the depressed tracks of the approach to the Union Station, occupying most of the space between the street and the river. On the opposite side of the street is the passenger terminal station of the Chicago & Northwestern Railway, with elevated tracks. The building is 389 ft. long, with a width of 270 ft. at the north end (Washington St.) and 239 ft. at the south end (Madison St.). In the main part of the building the entire Canal St. front extends to the full height of 26 stories, with only small offsets. Its width is 100 ft. up to the sixth floor, above which setbacks or offsets are made on the rear or river side. At each end a four-story wing extends from the rear to within approximately 30 ft. of the riverbank. Between these wings is a space, partly open and partly covered, to which the public will have access. This first-floor level is above Canal St., but owing to the inclined approach to the Madison St. bridge, this open space or concourse will be reached by a slight incline or ramp from Madison St., and a footbridge spanning Canal St. will enable commuters to walk between Madison St. and the elevated concourse of the Chicago & Northwestern Railway with-

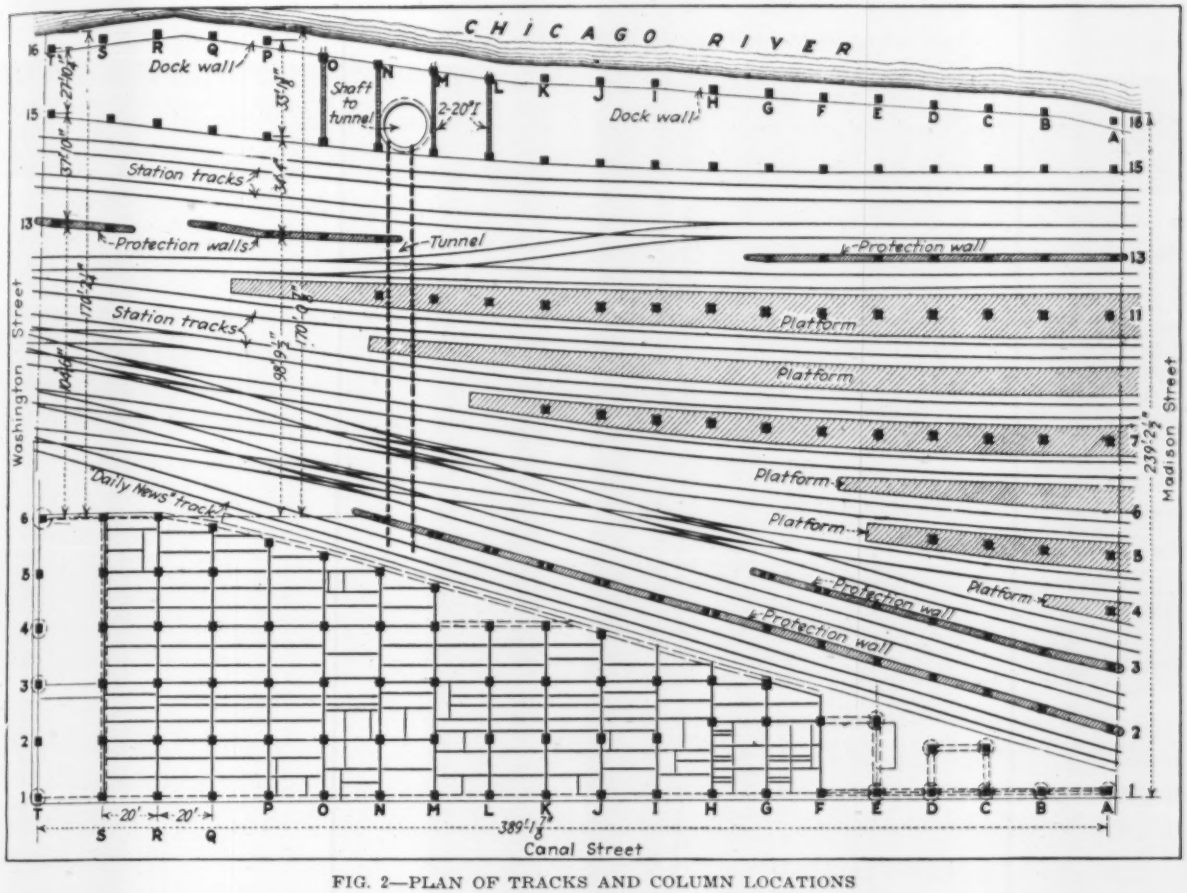


FIG. 2—PLAN OF TRACKS AND COLUMN LOCATIONS

out passing through the heavy traffic existing on Canal St.

For the first six floors the building will be occupied by the newspaper's departments, with printing presses on the second floor. Above this will be rented offices. The basement is about 4 ft. above the level of the tracks, which are a little below water level, and its rear forms a platform where rolls of printing paper can be unloaded from cars on a private sidetrack. At 7 ft. below Chicago city datum is a sub-basement, and at —26 ft. is a pump room. Still deeper, 45 ft. below datum, is a room at the west end of a tunnel 6½x7½ ft. in section leading to an elevator shaft just back of the concrete dock wall. This arrangement is to provide for receiving rolls of printing paper that may be delivered by barge or steamer. A driveway from Canal St. also provides for delivering these rolls by trucks.

Foundations—The foundations are of the usual Chicago type for large modern buildings, consisting of concrete piers built in wells sunk by open excavation. Those for the 26-story main building were carried down to rock at about 100 ft. below datum, but those for the smaller wings were stopped in the hardpan stratum at about 60 ft. and belled out to reduce the bearing load. In some of the deeper wells below the 75-ft. depth there was trouble with excessive water flow and running sand.

Columns and Framing—In the upper part of the main building there is a symmetrical column layout with I-beam framing and concrete floors. But for the wings and the southeast corner of the main building, where the track layout governed the location of columns, it was necessary to introduce plain and cantilever girders to support the superstructure columns, or trusses from which to suspend the floor framing above the tracks. These arrangements are shown clearly by the typical sections in Fig. 3. An unusual provision was that the framing should be so designed as to permit future removal of a part of the east or river side of the building. The reason is that only a portion of the site is owned by the *Daily News;* the remainder is leased from the Chicago Union Station Company and may revert to that company at some future time.

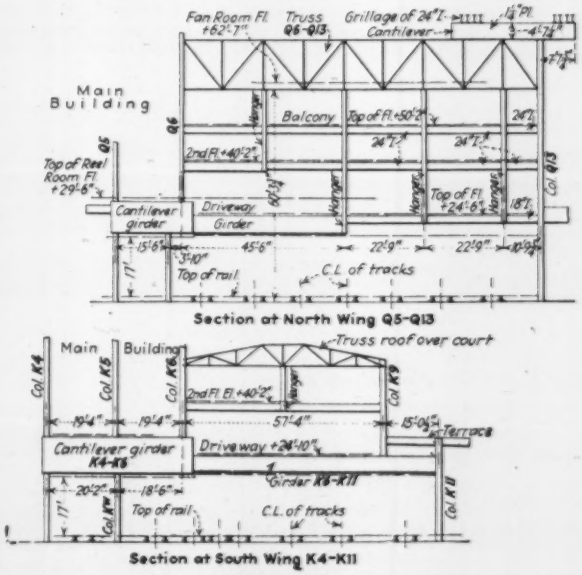


FIG. 3—SECTIONS OF WINGS
Above, trusses in north wing. Below, cantilever girder framing in south wing.

The actual column locations in the track space were determined by conference between the engineers for the building and the Union Station, the spacing between column centers and the over-all dimensions of the columns being written into the agreement covering air-rights development. Spans varied from 30 ft. to 102 ft. The overhead clearance required was 17 ft. above the rails, reduced by a circular curve to 8 ft. over the middle of the platforms. The minimum limit of side clearance was 7½ ft. from center of track to edge of column.

Cantilever Girders—The problems of supporting the south end of the structure across the tracks and of permitting future changes over a portion of the property covered were solved by the use of deep cantilever girders the supporting columns of which were 3 to 20 ft. outside or west of the property dividing line. These girders were generally below the first floor (second floor on the Canal St. front), but at some points they were placed in upper stories, with the framing suspended from them by hangers. Typical arrangements are shown by the cross-sections in Fig. 3, while details of the girders shown in the lower cross-section, *K-K*, are given in Fig. 4.

It will be seen that shallower girders are framed to the ends of the cantilever girders and have their opposite ends supported by the next row of columns. Where the cantilever arm would be too long if extended to the property line and was 15 to 20 ft. back of this line, the shallower girders were framed to them as shown, but as the shallow girders thus extend across the property line they will have to be removed for the possible future alterations covered by the agreement.

Pin connections were used in attaching the shallower girders to the deep cantilever girders, as shown in Fig. 4. They were used also for the attachments to the columns where the shallow girders came below the tops of the columns. The purpose of the pin connections is to remove all question of bending at these points. In fact, in some cases it was found impracticable to design a riveted connection of strength sufficient to take care of this bending.

Trusses—At the north wing, where the column spacing at track level exceeded 100 ft., it was necessary to introduce five 100-ft. trusses, as shown in Figs. 1 and 3. They have their west ends framed to columns of the main building while their east ends are supported by columns between the tracks. But at the location for one of these trusses no column could be placed. This difficulty was overcome by placing an A-frame between the two adjacent columns. In this triangular frame, 37 ft. 9 in. span and 20 ft. deep, the ends are framed to the sides of the columns and the apex forms the support for the truss.

These trusses, 14 ft. deep, have their chords at the third and fourth floor levels, while hangers from the

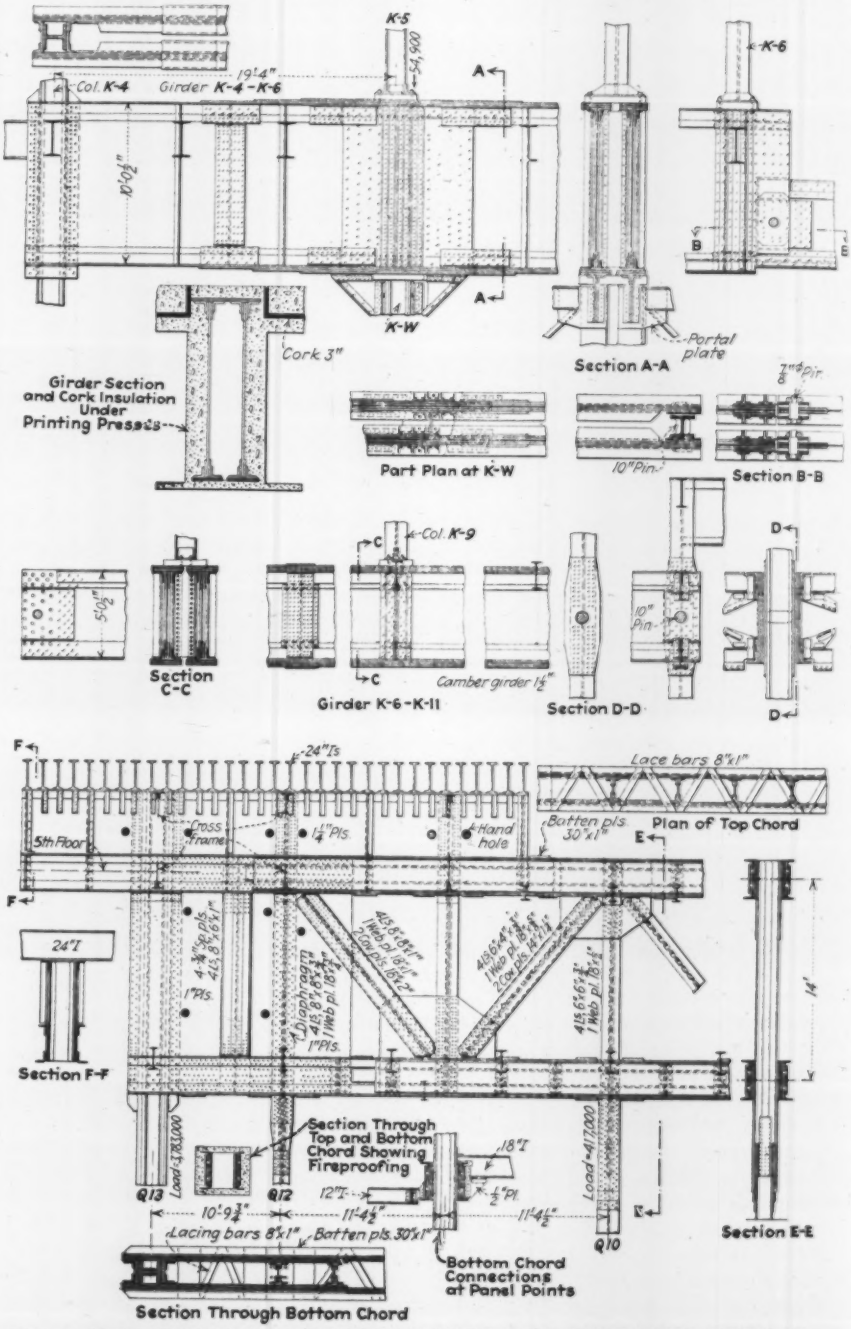


FIG. 4—HEAVY TRUSS AND GIRDER STRUCTURES IN DAILY NEWS BUILDING
At top, girders K-4-6 and K-6-11; below, 100-ft. truss with floor hangers

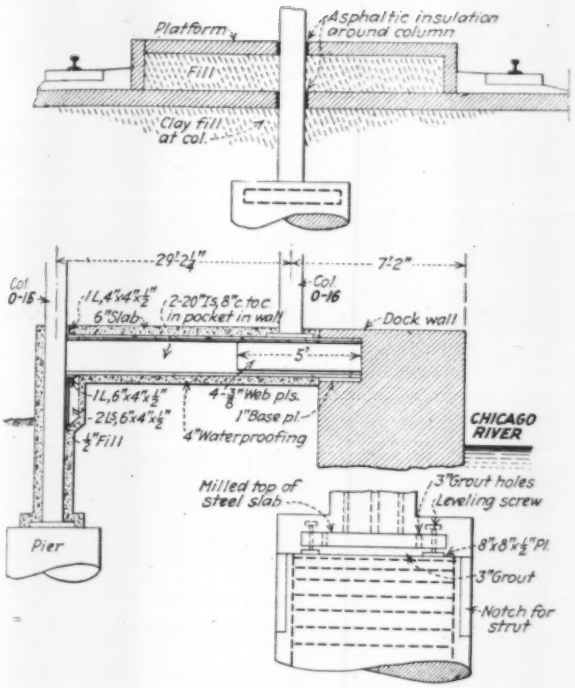


FIG. 5—STRUCTURAL DETAILS
At top, insulation of building columns from station floor. In middle, girder supports for columns at dock wall. At bottom; column base and pier cap.

truss posts carry the framing of the two floors below. An unusual feature in the design is that these trusses were built without splices in the chords. This plan was adopted on account of the heavy stresses, particularly in the bottom chords, where a tension splice would have required an excessive amount of material. These full-length chords, delivered at the site on railroad cars, were found to assist the erection. Above the top chord, at its river end, is a girder 30 ft. 10 in. long, and both the chord and girder have a cantilever projection of about 7½ ft. beyond the end post of the truss. Across these girders is laid a grillage of 24-in. I-beams, closely spaced. This curious arrangement is provided as a support for monumental statuary. Truss *Q–Q* is shown in Fig. 3, with some of its details in Fig. 4.

Miscellaneous Details—In the track floor all columns and beams are separated from the concrete platforms and floor slabs by a cushion or filling of clay in order to insulate the structure from vibration due to the movements of trains. This insulation is further completed by asphaltic packing around the columns where they pass through the slabs of the track floor and platforms, as shown in Fig. 5.

While the columns along the riverfront are seated mainly on the heavy concrete dock wall, it was necessary to place some of them just back of the wall, on account of clearances from the dock line. Foundation piers could not well be sunk, owing to the proximity of the wall and the large elevator shaft for the tunnel, and in fact such piers were not necessary, since these columns carry only the load of the court or plaza. The plan adopted, and shown in Fig. 5, was to carry each column on a pair of 20-in. I-beams, about 29½ ft. long, the inner ends of which were seated on angles riveted to the face of the first interior column, while the outer ends were seated on a base plate in a pocket cut in the dock wall. A 6-in. concrete slab over the beams forms a platform for handling rolls of paper when landed from vessels, and a 4-in. layer of concrete is packed under the beams as protection against corrosion.

To insulate the printing presses on the second floor and prevent their operation from causing vibration throughout the structure, they are mounted on a 12-in. slab of reinforced concrete, which is separated from the regular floor slab by a 3-in. layer of prepared cork. The supports and anchors of the presses are entirely in the upper slab and do not connect with the structural steel framing or the concrete floors. This detail is shown in the drawing of the girders in Fig. 3.

Smoke Removal—Since steam locomotives are operated on this railway terminal, provision had to be made for removing smoke, gas and steam and ventilating the track area under the building. The method consists of providing smoke chambers over the tracks and exhaust fans which discharge into ventilating shafts extending up through the building. The system is similar to that employed in the Union Station, as described in *Engineering News-Record*, May 29, 1924, p. 929.

Designers and Builders—The architects for this large air-rights building are Holabird & Root, for whom F. E. Brown was chief structural engineer during the period of its design and until he went into private practice (Smith & Brown, consulting engineers). His position was then taken by V. C. McClurg. The structural design was in direct charge of W. B. Gray, under Mr. Brown, until its completion. Joshua D'Esposito is consulting engineer for the Daily News Company, and C. E. Cox is chief engineer of the Chicago Union Station Company. The foundations were built by the John Griffiths & Son Company. For the superstructure, the Hegeman & Harris Company was the general contractor. All structural steel erection was handled by the Bass Construction Company. Part of the information given in this article is condensed from a paper read by Mr. Brown before the Western Society of Engineers.

Stress Analysis of Long-Span Three-Hinge Roof Trusses

Including Determination of Web Stresses From Previously Computed Chord Stresses by a New Graphic Method

By David A. Molitor
Consulting Engineer, Detroit, Mich.

THE SUBJECT of stresses in long-span three-hinged arch roof trusses is usually dismissed with a few remarks on wind forces and reaction conditions peculiar to the three-hinged arch, followed by a statement that the stresses in the members may be found by any of the common methods, preferably by drawing a Maxwell stress diagram. But for long-span, shallow trusses with many short web members, the Maxwell diagram is practically useless, and the method of moments involves many long lever arms with moment centers outside the limits of the drawing, so that lengthy computations become necessary.

The method presented herewith was evolved by the writer in an effort to obviate these difficulties, affording a simple process of stress analysis together with some important checks. It consists (1) of finding the reac-

tions and resultants of the external forces by well-known methods, (2) computing the chord stresses from the resultant polygon by the method of moments and (3) deriving the web stresses from the previously computed chord stresses by a new graphic method.

The following description covers the several steps in a complete stress analysis of the left half of a span for diagonal wind loads as illustrated on the accompanying diagram.

Reactions and Resultant Force—In determining the reactions and therefrom the resultant, the wind loads w_1 to w_6 are combined in a force polygon, and a trial equilibrium polygon AC is drawn using an assumed pole O', thus locating the resultant W and the straight closing line AC'. A line through the pole O', parallel to AC', will divide the resultant $A''C'' = W$ into two reaction forces P_a and P_c as shown. Since the resultant W must pass through the point A', the intersection of the two end rays of the trial polygon, it is thus found in direction and magnitude.

In constructing the final resultant polygon through the points A and C, the true pole O must first be located in the force polygon. Since the direction of the pole p must be parallel to the closing line AC, and the reaction R_2, acting at C, must pass through the right-hand hinge of the arch, $C''O$ is drawn through C'' parallel to R_2; by drawing p from e parallel to AC, the intersection O is determined as the true pole. By using the pole O to draw the resultant polygon from A to C, the actual end reactions R_1 and R_2 are given, which must intersect in a new point on the resultant W as a check.

The position of any resultant of externally applied loads to the left of C is thus located for any section of the arch, and the magnitude of any such resultant may be scaled from the force polygon.

Chord Stresses—The chord stresses are computed by the method of moments. Thus for member FG, the center of moments is n and the resultant in the bay F is 20.7 kips, acting with a lever arm of 22.1 ft. Also, the lever arm from n to the member is 14.5 ft. Hence the stress in $FG = 20.7 \times (22.1 \div 14.5) = 31.6$ kips. Similarly all other chord stresses may be computed.

Web Stresses—A simple graphical method is used to determine the web stresses which are derived from the chord stresses, obtaining one set of values from the bottom chord and a duplicate set of values from the top chord. In the example here given all the web stresses are found from the bottom chord stresses, while only a few are derived from the top chord to show how to insert the panel load w_3.

This method of determining the web stresses has the advantage of simplicity and accuracy and affords a check not only for the web stresses but also for the previously computed chord stresses which require no checking until a disparity in any one pair of results for a certain web member is discovered. The method in its entirety is practically free from cumulative errors which are predominant in the ordinary stress diagram.

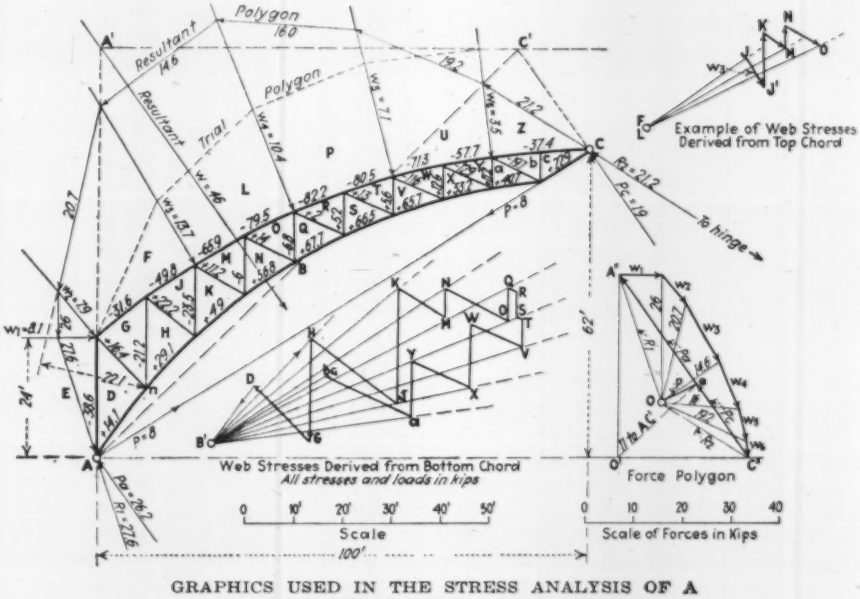
The following procedure is used to derive the web stresses from the computed bottom chord stresses: From any point B' as a pole, a series of rays is drawn parallel to the bottom chord members, successively from A to C.

The computed bottom chord stresses are next laid off on the respective rays $B'D$, $B'H$, $B'N$, etc., using any convenient scale of forces, in this case the same scale as used in the force polygon. The web stresses must fit between the points D, H, K, N, etc., so that all the members around a given panel point, as n, will appear in a counterclockwise order, thus $D'B$, $B'H$, HG and GD, to form a closed polygon. In each such partial stress diagram all stresses are known except the two web stresses, which are thus determined in direction and amount.

The direction of each stress is found by following around the partial stress diagram, starting with the two chord members of known direction. Sometimes this direction may be clockwise, as when the bottom chord members are in compression. In the case where some of the chord members of the same chord are in tension while others are in compression, it is necessary to draw the tension chord rays in a positive direction from the pole B' and the compression chord rays in the opposite direction.

The stresses in the web members JK, KM, MN and NO have also been derived from the loaded top chord, as an illustration. The order in which the members ML and FJ and the load w_3 are arranged is immaterial as long as the known quantities are grouped together, permitting the two unknowns to close the polygon. The accompanying illustration shows a grouping which retains the system of rays from a common point as was done for the unloaded bottom chord.

When dealing with vertical loads only, the horizontal thrust is computed and the final resultant polygon is drawn without the trial polygon. To compute the horizontal thrust, moments are taken about C of all forces to the left of C, including the vertical reaction at A. The sum of these moments divided by the rise of the arch gives the horizontal thrust.



GRAPHICS USED IN THE STRESS ANALYSIS OF A 200-FT. THREE-HINGED ROOF TRUSS

Design of 11,000,000-Yd. Earth Dam for Saluda River Power Project

Hydro-Electric Development on Saluda River in South Carolina Costing $22,000,000 Includes a Semi-Hydraulic Fill Dam Containing 11,000,000 Cu.Yd., Rising 208 Ft. in Height and Having a Crest Length of 1½ Miles

By Arthur R. Wellwood
Resident Engineer, Murray & Flood, Engineers, New York City

About eighteen months ago construction was started on the Saluda dam at Dreher Shoals, on the Saluda River 10 miles west of Columbia, S. C. The dam will impound water for the generation of electric power and will be the largest high earth dam in the world, 208 ft. high, 7,838 ft. long on the crest, 1,150 ft. maximum width, and will contain 11,000,000 cu.yd. of fill. Fig. 1 shows the location and extent of the development, which involves an estimated expenditure of $22,000,000. It is being made by the General Gas & Electric Corporation of New York for its subsidiary, the Lexington Water Power Company of Columbia. Contracts for the delivery of power necessitate completion by September, 1930.

The initial installation of 200,000 hp. of prime mover capacity in the power plant, consisting of four generating units, will deliver 300,000,000 kw.-hr. of primary electrical power annually while operating under a maximum head of 183 ft. and under an average head of 165 ft. The ultimate capacity of the plant is 300,000 hp., which will be made possible by the addition at a later date of two generating units.

Lake Murray, named after William S. Murray, of Murray & Flood, as the storage reservoir will be known, will be 40 miles long and 14 miles wide at its widest point. It will cover an area of 78 square miles of land, have a shore line of 520 miles, contain 2,300,000 acre-ft. of water and require approximately ten months to fill in a year of average streamflow.

Project Structures

The project structures, besides the great dam, include a spillway, diversion conduits, penstocks and intakes, and the power house, surge tanks and substation. The structures of principal civil engineering interest are the dam, the spillway and the penstock and diversion conduits through the dam. These structures will be chiefly emphasized here, together with the surveys and other planning and preparatory work in a succeeding section.

Dam Materials and Structure—The location and plan of the dam are shown by Fig. 2. The land area covered is 110 acres and the alignment consists of three tangents and two 4 deg. curves. Many trial layouts of the dam were computed with the center line of the dam so located as to take advantage of different topographic features. The adopted location proved the most economical, and it also best fitted the topography; sub-surface explorations determined its practicability from the standpoint of good foundations.

The area adjacent contained abundant material of excellent quality for the construction of the dam—decomposed granite gneiss, decomposed schist (hornblende), brown loamy clay, brown clay, red clay, and impure sand.

The depth of overburden in the borrow area was determined by wash borings made over the entire area shown in Fig. 2, which is approximately 2,700 acres. Of this, 430 acres will be required for the dam material. More than 1,800 holes were drilled at intervals of approximately 200 ft. along the contours rather than on arbitrary straight lines. In addition to the wash borings, test pits were dug at representative locations in the borrowpit areas and samples of the material taken from different elevations were subjected to various tests in order to determine their suitability for use in the dam and for other design data such as stability for slope determinations, kind and size of core and homogeneity of under-surface layers.

Based on the materials studies and other survey data, the dam sections shown by Fig 3 were adopted. As shown, the design of the dam provides for a clay core to be formed through the creation of a segregation pool between the upstream and downstream dikes of the dam. Through the use of pumping equipment mounted on barges in the middle third area of the dam the fine particles will be sluiced from a portion of the material in the dikes and carried into the segregation pool to form an impermeable core. The width and depth of the segregation pool will be controlled so that the middle sixth of the dam will be composed of material of which at least 65 per cent will pass a screen having 100 meshes per linear inch. This will leave a coarse material behind to assist in stabilizing the dikes which retain the segregation pool.

When the segregation pool reaches El. 340, sluicing

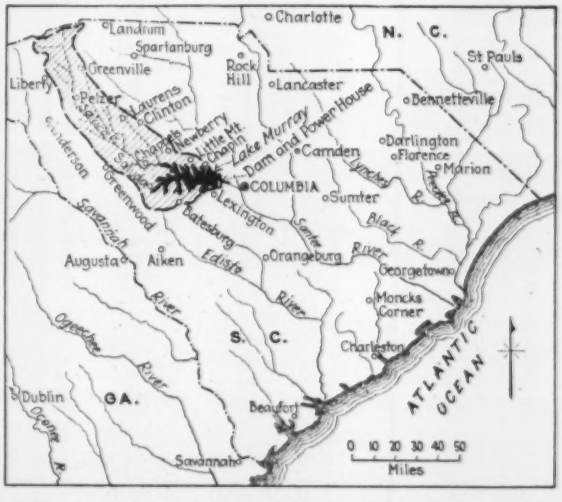


FIG. 1—MAP OF SALUDA RIVER HYDRO-ELECTRIC DEVELOPMENT IN SOUTH CAROLINA

operations will cease and selected materials will be dumped into the pool to El. 350. The pool will be discontinued at this point and the remainder of the dam will be built by consolidating selected materials.

Following the median line a core trench will be excavated from one end of the dam to the other. This trench varies in width and depth, being largest in the deepest portion of the dam and diminishing in size at the ends. It will be carried down to ledge rock or other sufficiently impervious material.

A rockfill will be constructed at the dowstream toe of the dam across the deepest portion of the valley (see Fig. 2). This fill will have side slopes of 1 on 1½ and will be made of sound rock of such sizes and so placed as to prevent its being displaced or eroded by the flow of drainage water from the dikes through it. The upstream face of the rockfill will be covered with fine rock prior to the trimming of material from the outer slope of the lower earth dike against the rockfill. The object of this covering is to prevent the material in the earth dike, when saturated, from passing into and through the voids of the rock.

The upstream face of the dam, between the lowest draw down limit (El. 300) and 7 ft. above the full reservoir level (El. 367) will be covered with riprap. The riprap will vary uniformly in thickness normal to the face of the dam from 1 ft. at its lowest elevation to 2 ft. at its highest elevation. It will be composed of one-man stone or of gravel.

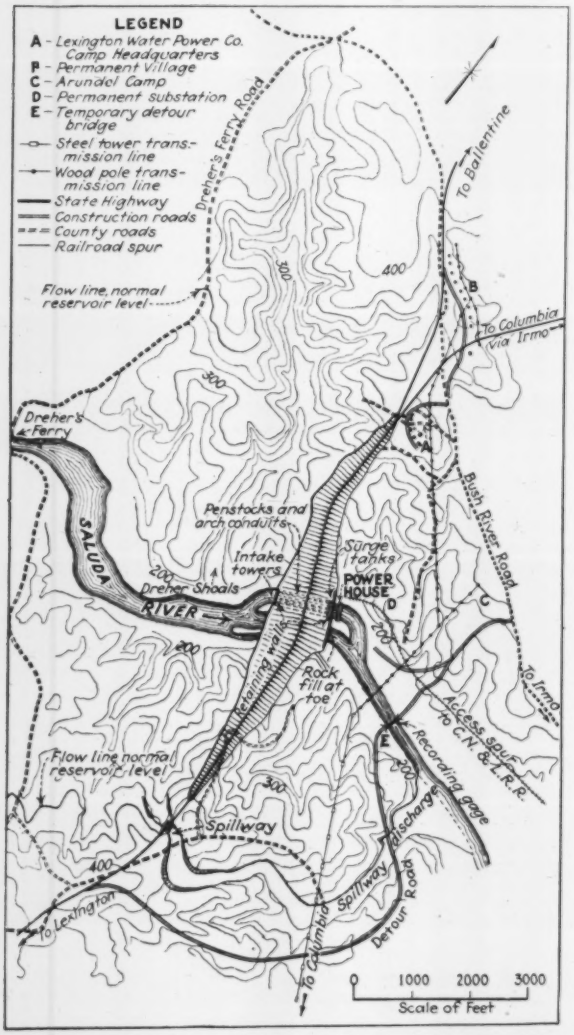


FIG. 2—PLAN OF SALUDA DAM, SHOWING ROADS, RAILWAYS AND CONSTRUCTION CAMPS

The top of the dam will be paved with an 18-ft. concrete roadway which will be taken over by the State Highway Department of South Carolina as a part of the state highway system.

Spillway Design and Structure—A spillway with ample capacity to pass floodwaters is located about 500 ft. from the south end of the dam in the same general alignment as the dam (Fig. 2). A large factor of safety was applied in its design, and its capacity, taken in combination with a 5-ft. rise in the reservoir above normal high-water level, is capable of carrying away 2½ times the maximum flow which resulted from the Aug. 10, 1928, flood—the greatest flood known in a period of twenty years.

The spillway will consist of a concrete ogee overflow section, the base of which will rest on rock at about El. 325, the lip reaching El. 340. Maintenance of the normal lake level at El. 360, 20 ft. above the spillway lip, will be obtained through the use of four tainter gates, the dimensions of which are 37½x25 ft.

The highway that will cross the top of the dam will continue across the spillway supported by the same piers that support the gates. The floodwaters will pass from the spillway into a natural channel formed by a valley, and the discharge will enter the river about ¾ mile below the dam.

Diversion Conduit and Penstocks—Four steel plate pipes 1⅛ in. thick, 16 ft. in diameter and 986 ft. long and one semicircular concrete arch conduit 48 ft. in diameter, 23 ft. high and 1,043 ft. long extend through the dam. After they have served their purpose as diversion conduits the four steel pipes will be used as penstocks to the power house, while the concrete arch provides a location for the installation of two additional penstocks at a later date. The location, dimensions and structural features of these conduits are shown in Figs. 2, 3 and 4.

In constructing the conduits trenches were excavated in the rock about 9 ft. deep and concrete cradles about 18 in. high, on which the pipe was laid, were placed approximately 16 ft. apart. When the steel pipe was assembled, the spaces between the walls and pipe were filled with concrete and an arched concrete casing covering the pipe was provided. Before the casing was poured internal bracing was constructed in order to maintain a true circular pipe.

Power Plant—The power house will be of the indoor type and its superstructure will be constructed of steel and brick. The controlling dimensions of the building are: length, 250 ft.; width, 56½ ft., and height above operating floor, 95 ft.

The initial installation will include four generating units of 32,500 kw., each at 0.8 power factor. The diameter of each generator is 26¼ ft. and the rotor and 29-in. diameter shaft of each generator weigh 200 tons. The diameter of the waterwheel at the runner band is 12¾ ft. Provision is made for extending the power house to include two more units, the penstocks for which will lead from the arch intake through the arch conduit.

A working bay is provided at the north end of the power house in order to allow any unit to be repaired under cover, and the railroad which has served during

construction will ultimately connect with the working bay of the power house and also with the outdoor substation, thus reducing the loss of time in work of repairs and replacement.

Between the power house and the downstream retaining wall there will be erected a surge tank for each unit (Fig. 3). These tanks will be of the differential type 215½ ft. in height. The risers to the surge tanks are 14 ft. in diameter. The capacity of each tank is 1,000,000 gal.

The outdoor substation will be constructed about 1,000 ft. downstream from the dam and will contain all transforming, switching and metering equipment which does not require cover protection yet is necessary for controlling and raising the voltage for long-distance transmission at 110,000 volts.

Drainage Area and Hydrography

The Saluda River drainage area at the Dreher Shoals dam site is 2,396 square miles. The drainage basin is long and narrow.

The fall in the Saluda River from the dam site to the upper end of the pond is attained in a series of shoals with stretches of comparatively slack water between; the average gradient is about 4.7 ft. per mile along this course of the river. In the length of the proposed reservoir, from tailwater to static normal headwater at the vanishing point of the flow line, there are three average slopes. The first 10 miles above Dreher Shoals slopes at the rate of 11 ft. per mile, in the next 20 miles the average slope is 4 ft. per mile and in the last 10 miles, to the point where the 360 contour intersects the normal water surface, the average slope is only 0.35 ft. per mile.

The records indicate that the average yearly rainfall in the drainage area of the Saluda River varies between 65 in. at its source and 42 in. at its mouth. Approximately 42 per cent of the precipitation enters the river as runoff. The average flow at Dreher Shoals is approximately 3,700 sec.-ft. The maximum flood that has occurred at the same point is estimated to be approximately 100,000 sec.-ft.

The engineering and field investigations necessary for the proper design and location of the project works were carried on during 1927 by the field engineering forces of Murray & Flood, with the writer directly in charge.

In addition to the investigation of a suitable site and for materials for the dam, land surveys, clearing and grubbing, camp construction and other preliminary operations were required.

Land Surveys—South Carolina is one of the thirteen original states and has never been sectionalized. The properties therefore are described only by metes and bounds. There are no plat books and in many cases plats and even land transactions had never been recorded. This complete lack of basic information made the task of acquiring land difficult, and in order to overcome as much of the handicap as possible field investigations and surveys were started and the data collected were rapidly put into useful form.

A large map drawn to scale of 2,000 ft. to the inch was constructed from such government maps as were available, and using this map as a base a preliminary land atlas was started. The data for this map were gathered in the field either through the collection of old plats held by land owners or by descriptions given by natives and sketched approximately by the engineer assigned to this task. This map served a very useful purpose until the final atlas based on actual surveys was completed. More than 1,000 individual tracts of land in the reservoir area averaging about 125 acres in size were surveyed and as many as 25 survey parties were used at one time in this accomplishment.

A malarial survey was conducted under the joint supervision of the South Carolina State Board of Health, the International Health Board and the Lexington Water Power Company. The main objects of the survey were to determine the existing malaria incidence before the water was impounded or the land cleared and the proper procedure of practical control for the area affected by the project.

In addition to the land surveying it was necessary to make surveys of the flow lines, the project boundary line and the lower and upper limits for clearing opera-

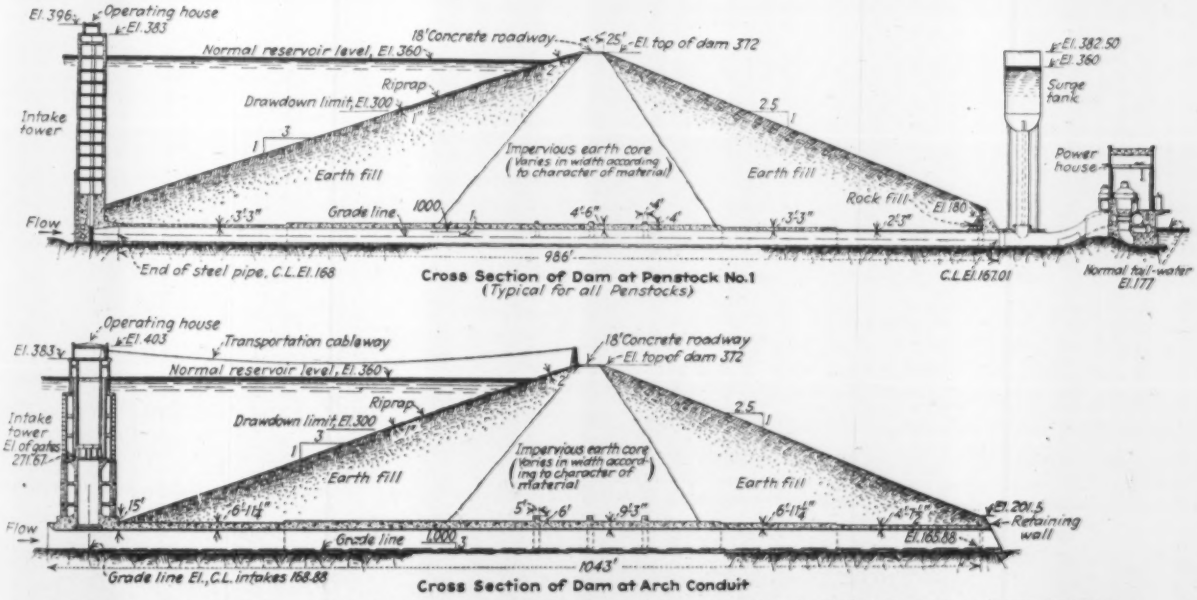


FIG. 3—SECTIONS OF SALUDA DAM, SHOWING PENSTOCKS, DIVERSION CONDUIT AND POWER HOUSE

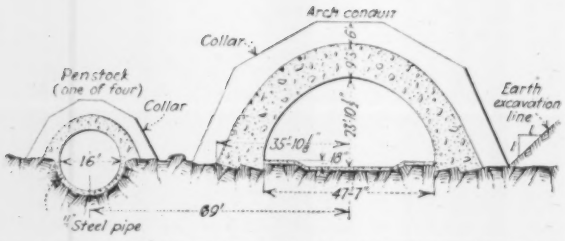


FIG. 4—SECTION OF PENSTOCK AND DIVERSION CONDUIT

tions, and to develop detailed topography in the dam site area.

Access and Housing—The contract covering the construction of the diversion conduits, intake towers and earth dam was awarded to the Arundel Corporation, of Baltimore, on Aug. 19, 1927. On Sept. 5, 1927, the first part of the contractor's equipment arrived.

A few months in advance of letting the contract the owners of the project started the erection of the temporary and permanent buildings necessary for their construction and engineering forces near the scene of operations. An administration building, and engineers' building, a bunk house, a mess hall, a garage, a storehouse and the necessary sanitary conveniences were constructed at a location overlooking the site of the dam.

Nine houses of the bungalow type which will eventually be occupied by members of the permanent operating forces of the power plant were erected on a hill a short distance from the northerly terminus of the dam. These houses are at present being occupied by various members of the construction and engineering forces on the job. In addition to these houses the company also built a clubhouse, a church and two tennis courts. Deep wells were driven and connected to large water tanks so located as to serve the various buildings. In reality a small permanent village was created, and a street-lighting system, nicely kept-up lawns and shade trees add to its attractiveness and its dignity.

The Arundel Corporation built its construction camp on the north side of the river about a half-mile below the dam, and in addition to white and colored bunk houses and mess halls it constructed its own office and commissary buildings.

An access railroad approximately 3 miles long was started in the early part of September, 1927, and was completed about the middle of November of the same year. It connects with the Columbia, Newberry & Laurens Railroad. This road was necessary for the transportation of the contractor's plant, the aggregates and cement for concrete and for other materials required in the construction of the project works.

Temporary construction roads were built in and about the dam site, direct telephone trunk lines were constructed between the dam and Columbia and arrangements were made with the postal authorities for the delivery of mail to the field offices.

Clearing and Grubbing—The area to be covered by the dam was cleared of all trees and brush. The grass was then either burned off or cut and removed. The upstream and downstream thirds of the dam were grubbed of all stumps and roots larger than 1 in. in diameter to a depth of at least 6 in. below the surface of the ground and all ground litter was removed. In the upstream third all natural or artificial deposits of small loose rock, boulders and gravel deposits were removed. The middle third of the entire area to be occupied by the dam was stripped of sod and loam to an average depth of about 2 ft. and all stumps and roots larger than 1 in. in diameter were removed to a depth of 6 in. below the new surface.

Summary of Quantities
Saluda Semi-Hydraulic Fill Earth Dam

Height—208 ft.
Crest length—7,838 ft.
Slopes—upstream, 1 on 3; downstream, 1 on 2½.
Crest width—25 ft.
Base width—1,150 ft. (max.)
Freeboard—12 ft.
Alignment—three tangents and two 4 deg. curves.
Earth excavation, penstocks—283,000 cu.yd.
Rock excavation, penstocks—46,000 cu.yd.
Concrete, intakes, penstocks, conduit and retaining walls—75,750 cu.yd.
Reinforcing—504,815 lb.
Structural steel—1,180 tons.
Clearing, dam area only—99 acres.
Stripping over middle third—110,664 cu.yd.
Excavation, core trench—100,000 cu.yd.
Excavation for rockfill at toe—20,000 cu.yd.
Earthfill—11,000,000 cu.yd.
Rockfill—10,000 cu.yd.
Riprap—75,000 cu.yd.
Roadway top of dam—16,000 sq.yd.
Reservoir clearing—40,000 acres.
Reservoir area—78 square miles.
Reservoir capacity—2,300,000 acre-ft.

Clearing the area to be covered by Lake Murray presented a large task. Approximately 40,000 acres of land must be cleared in order to conform to the regulations of the Federal Power Commission and the State Board of Health of South Carolina. Much of the wooded area was found to contain a great deal of valuable merchantable timber. At the outset 35 sawmills were in operation and upward of 1,200 men were employed in clearing the land and cutting the lumber. The small growth is being assembled in piles and burned. The large trees are being cut down and manufactured into lumber and shipped to the various markets of the country. Clearing the land is being done both by company forces and by individual contractors—farmers who formerly owned the lands in the reservoir area.

A timber survey of the reservoir area disclosed that 100,000,000 ft. b.m. of merchantable lumber was available. Two-thirds of the timber consists of pine and oak of several varieties, the remaining third being red and black gum, poplar, sycamore and red cedar.

Foundation Conditions—Bedrock, a dense stratified gneiss standing almost vertical, is found approximately at El. 167. Across the streambed the middle third area was stripped to this rock. The remainder of the middle third and both outer thirds were stripped of all soft materials and foreign matter to a clean hard formation known as Southern red clay.

Engineers and Contractors—The general contract for the construction of the entire project was given to the construction division of W. S. Barstow & Company, Inc., which contracted with the Arundel Corporation, of Baltimore, for the construction of the conduits, intake towers and dam.

The designing and supervising engineers for the development are Murray & Flood, of New York City, and they have retained A. S. Crane, of New York City, as their consultant on the earth dam and other hydraulic matters.

Third of a Series of Five Articles

Basic Principles of Concrete-Making

By F. R. McMillan
Director of Research, Portland Cement Association, Chicago

III—Combining Aggregates With Paste To Make Workable Concrete

How Grading Influences Quality, Economy and Workability—Trial Proportioning the Best Method—Limiting Sand Ratios—Interrelation of Mix, Water Ratio, Cement Factor and Consistency—Possibilities of Improvement

IN THE two preceding installments of this series it has been demonstrated that for *plastic mixtures* (to re-empha size, a plastic mixture is one in which all the space between aggregate particles is thoroughly filled with the cement-water paste) the properties of the concrete are principally determined by the properties of the hardened paste. It has also been shown that the properties of the hardened paste can be completely controlled through the relative proportions of cement and water and the degree of curing attained. Proportioning concrete for a given purpose, therefore, consists in the two steps already pointed out:

> First, to select such proportions of water and cement and such conditions of curing as will produce a paste to meet the requirements for the particular structure as to strength and watertightness; and
>
> Second, to find that combination of aggregates and paste which will give a plastic mixture remaining homogeneous during placing and after it is in place.

It is with the second step of this method of proportioning concrete that this article is concerned. In this treatment consideration will be given to the factors influencing the relative quantities of aggregate and paste and the proportions of fine to coarse aggregate which are necessary to give a plasticity that will meet the requirements of handling and placing. It will be shown that no elaborate theories or calculations are required to arrive at suitable proportions but rather that the desired results can be attained by a few simple trials and the exercise of judgment.

Combination of Aggregates and Cement Paste

Many have found difficulty in translating the results of their study and experience with concrete, on the basis of fixed proportions of cement and aggregate, to the basis of this new method where the quality of the paste is fixed by the water-cement ratio, leaving the aggregate proportions as a secondary consideration. Once this difficulty is overcome, it will be found that the method is not only easy to grasp but exceedingly helpful in explaining many things that were known to be true only through experience. However, one point to be kept in mind throughout this discussion is that no method of proportioning concrete should be made an excuse for neglecting the other details of construction. Selecting the proportions of ingredients to meet the requirements of the work is only one of the necessary steps in successful concrete construction. It goes without saying that the materials must be suitable; that the mixing, transporting and placing must be such as to insure a homogeneous mass throughout the structure; and that adequate protection must be provided to obtain the curing necessary to develop the strength and watertightness required.

The method of selecting proportions is simple and provides a direct means of applying the basic principles of quality to job control. It may well displace the use of arbitrary proportions as well as the more cumbersome procedure of calculating by involved processes a grading of aggregate which, with a given water-cement ratio, will give the required consistency.

The method also possesses certain advantages which are useful beyond the mere matter of arriving at the proportions. It gives a simple means of comparing various aggregates or aggregate combinations on the basis of workability and economy. It provides for ready adjustment of the mix where such is required. Through these two it makes the knowledge of the experienced foreman an asset to the work, for when held to a paste of fixed quality, his experience in meeting difficult placing requirements can be utilized without sacrificing quality.

Significance of Grading of Aggregate—The grading of aggregates has occupied a very prominent place in the literature of concrete. This is eminently right and proper when thinking in terms of certain definite mixes, for with a fixed quantity of aggregate per unit of cement the grading is a major factor in strength and other desirable qualities. That this is true can be seen in the curves of Fig. 19, where in the upper left-hand drawing are shown the strengths plotted in terms of the density from a group of concretes of three different mixes based on a rather wide range of combinations of fine and coarse aggregates of different gradings. Density, as the term is used here, is the ratio of the sum of the absolute volumes of cement and aggregate to the volume of the concrete. The different densities in these tests resulted from the different gradings.

An inspection of these upper left-hand curves in Fig. 19 shows a fairly regular relation between compressive strength and density for a particular mix, there being a separate curve for each of the three mixes. It is seen that the compressive strength for any mix decreases as the density decreases; for example, with the 1:5 mix (one sack of cement to 5 cu.ft. of mixed aggregate), a change in grading which reduces the density from 0.85 to 0.75 reduces the strength by more than half. This change in strength is not due, as is so apt to be thought, to the change in grading as such, but results from the difference in water required to maintain the given consistency. The difference in water required is brought

out by the lower curves in Fig. 19, where the same data are plotted, but on the basis of density against water-cement ratio. In this lower diagram each mix and consistency gives a separate relation between density and water quantity, showing that density is not a measure of concrete quality that can be universally applied. Density is a measure of quality only when the mix and consistency remain unchanged, since it is only for these conditions that it is an accurate measure of water required.

Before leaving the matter of density the curve at the upper right should be studied. In this, the same data are again plotted, but this time as strength against water-cement ratio. Here it is seen that all of the mixes and consistencies, which required separate curves in the two other diagrams, are interpreted by a single curve—showing the universal character of the water-cement ratio law.

Grading as an Economic Factor—To bring out more fully the significance of grading under the two different methods of proportioning—by fixed mixes or for a given quality of paste—Table IV has been prepared. In this table are three mixes from the group of tests forming the basis of Fig. 19, selected to show an extreme range

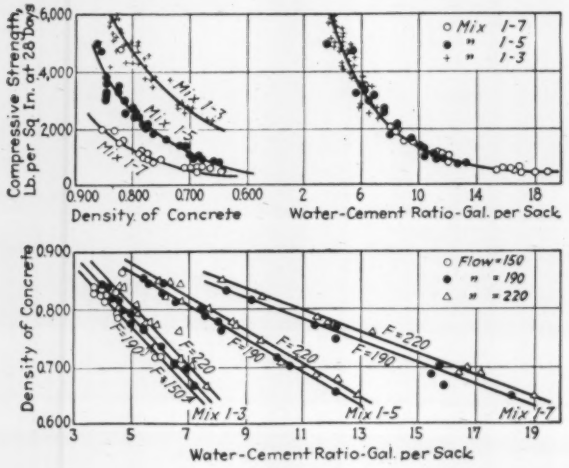


FIG. 19—DENSITY, STRENGTH AND WATER-CEMENT RATIO
0 to No. 4 sand and No. 4 to 1½-in. gravel.

in grading in order to bring out the factor of economy more clearly; it is not likely that such a range in grading would ordinarily be encountered in the materials available for a single job. The first two mixes in the table furnish a comparison on the basis of arbitrary proportions (1:5 mix), and the first and third a comparison on the basis of like quality of paste. The latter comparison is approximately fair but is not quite exact, as the water ratio for the third mix is a half-gallon lower than for the first, with a correspondingly higher strength, due to the fact that there were no mixes between the 1:5 and 1:3; a mix of 1:3½ would have given about the same water ratio and strength.

In the first mix in Table IV the aggregate is a good combination containing 36 per cent coarse sand and 64 per cent graded coarse aggregate, whereas in the second and third mixes the aggregate contains 59 per cent fine sand and 41 per cent coarse aggregate of almost no range of sizes. In comparing the two 1:5 mixes it is seen that because of this difference in grading it was necessary to increase the water content 3½ gal. per sack in order to

TABLE IV—COMPARISON OF MIXES

Mix by Dry Volume		Aggregates Used		Water-Cement Ratio, Gal. per Sack	Slump, In.	Density of Concrete	Cement, Sacks Per Cu. Yd.	Cost*	Compressive Strength 28 Days, Lb. Per Sq. In.
Mixed Aggregate	Separated Aggregate	Fine	Coarse						
1:5	1:1.95:3.80	0–No. 4	No. 4–1½ in.	6.0	3.0	0.85	5.4	$6.66	3,600
1:5	1:3.46:2.60	0–No. 14	¾–1½ in.	9.5	3.3	0.75	4.8	6.05	1,600
1:3	1:2.07:1.55	0–No. 14	¾–1½ in.	5.5	2.5	0.76	7.5	7.77	3,800

*Cost per cubic yard of concrete for materials only. Cement at $2.80 per barrel; sand and gravel at $2.50 per cubic yard.

maintain a plastic consistency; the increase in water content resulted in a reduction in strength of 2,000 lb. per sq.in. with only 10 per cent reduction in cost. On the other hand, by comparing the first and third mixes it is seen that, with the quality of the paste fixed (definite water ratio), the desired strength is readily obtained with the unfavorable grading, though at an increased cost.

The point it is desired to emphasize by this illustration is that when proportioning concrete for a definite quality through fixing the water content of the paste, the grading of the aggregates becomes principally a question of economy and workability. In this illustration it is seen that an extraordinary range of gradings, which in 1:5 mixes reduces the strength more than half, represents only a matter of 16 per cent increase in cost when compared on the basis of concrete of constant strength. It can be shown from the figures in the table that the sand and the well-graded coarse aggregate of the first mix could each carry an extra cost of $1 per cubic yard before it would be more economical to use the materials in the third mix at the prices assumed.

If the illustration of Table IV with its extreme range in grading is carefully studied, it will be apparent that intermediate combinations of aggregates would show intermediate results as to mixes and cost. From such a study it can be realized that many possible combinations which give low strengths when compared with the first mix on the basis of 1:5 concrete might give favorable costs when compared on the basis of equal strength by using a paste of the required quality—that is, the extra quantity of paste might easily be offset in cost by favorable combinations of cheaper aggregates.

Supplementing the foregoing illustration, it is of interest to compare a number of mixes in which the grading varies within the range ordinarily encountered in concrete materials. Such a comparison is offered by Fig. 20, which shows four groups of mixes in which the quality of the paste in each group is fixed by a constant water-cement ratio, while the grading is varied by changing the ratio of fine to coarse aggregate. In these mixes the sand and gravel were of good grading, and the combinations with the paste were such as to give a constant slump of 6 in. for all water ratios. It will be noted that the mixes for each group vary from an all-sand mix to one in which the amount of coarse aggregate is at or beyond the probable limit of workability.

These mixes are plotted in the lower diagram of Fig. 20 in the manner used in Fig. 1 of the first article of this series, in which the ordinates represent one unit volume of concrete divided to show the absolute volume occupied by each of the ingredients. In this diagram the fine and coarse aggregates are shown separated.

In order to make the similarity with Fig. 1 complete,

an amount of combined water has been assumed which bears the same ratio to the amount of cement as used in Fig. 1 for similar water-cement ratios. As in Fig. 1 also, air voids have been ignored. These would be about 3 per cent for the all-sand mixes and less than 1 per cent for the other mixes. In the upper diagram are plotted the costs for the materials in 1 cu.yd. of concrete for each of the mixes in the lower diagram.

The differences in grading in Fig. 20 can be compared by the ordinates representing the total amount of aggregate in the unit volume of concrete. Except for the all-sand mixes it can be seen that quite a variation in the proportions of fine and coarse aggregates results in only a small change in density—that is, in the total absolute volume of solids in the concrete. More significant still is the small difference in cost between those mixes for each water-cement ratio which lie within the range of what would likely be used. Of course, the cost comparison would vary with each combination of prices assumed, but it can be seen from the analysis in Fig. 20 that, when designing mixes on the basis of the quality of the paste, considerable latitude is presented for varying the proportion of fine to coarse to take advantage of the existing price schedule. This is the big advantage of such a method of design. It makes possible the best utilization of available materials and at the same time insures the desired quality.

Grading as a Factor in Workability—In the preceding paragraphs it was pointed out that, when designing concrete mixtures on the basis of a definite water-cement ratio, grading of the aggregates becomes principally a question of economy and workability. In the discussion of economy proper workability was assumed—in fact, the limit of workability was made one of the limits of economy. Elsewhere in these articles emphasis has been placed on matters of placing, and the need for plastic and homogeneous mixtures has been stressed, particularly where the concrete must be watertight. In selecting the individual aggregates to use, and the proportion of fine to coarse, the requirements of placing and the prevention of segregation must receive first consideration.

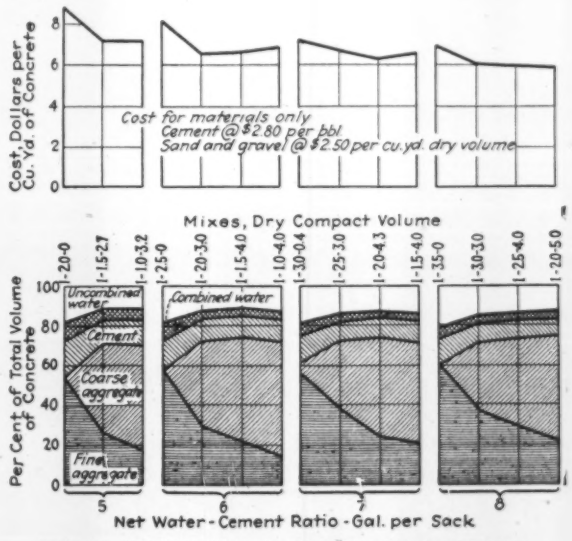


FIG. 20—COMPARISON OF MIXES FOR CONSTANT CONSISTENCY

Coarse aggregate: No. 4 = 1½-in.; weight, 108 lb. per cubic foot dry compact volume. Fine aggregate: 0 = No. 4; weight, 114 lb. per cubic foot dry compact volume. All mixes for slump of 6 in.

Trial Proportioning—With a given set of materials, the best method of arriving at the proper consistency is by trial, using the fine and coarse aggregates in different proportions with a paste of the required water-cement ratio. These trial batches should be observed for placeability and segregation. Mixtures too high in coarse aggregate will place with difficulty, and in the wetter mixes will tend to increase segregation. On the other hand, mixes with a high proportion of fine aggregate place more easily and (unless the sand is very coarse) do not tend to segregate. In the case of very coarse sands there may be a tendency to separation of the paste from the aggregate mass which is not overcome by increasing the sand proportion. Such separation can be prevented only by adding fines to the aggregate or by stiffening the paste through the use of a lower water-cement ratio.

Segregation in Placing—One of the most serious types of segregation is that which occurs during placing and after the concrete is in place, due to the use of too wet a mixture. As pointed out in the first article in the discussion of overwet mixes, such segregation results in the accumulation of water at the surface as the placing progresses, causing laitance layers and porous concrete immediately below. When these fluid mixes are used, the water-cement ratio of the mass will vary from bottom to top, with consequent differences in strength and watertightness in the various layers. The remedy lies in control of the plasticity through the gradings and proportions of aggregates.

Limiting Factors in Aggregate Proportion

From the study of Fig. 20 it was seen that a considerable range exists in the proportions of aggregates which can be used with a given cement paste without greatly affecting either the density of the concrete or the cost. For the unit prices assumed, it can be seen that cost alone would act as a deterrent to the use of mixes too high in fine material. In the other direction, the matter of workability would act to limit the use of too high a proportion of coarse aggregate. With intelligent supervision, under conditions where costs approximating those assumed prevailed, it would be safe to leave the matter of selection of proportions to be adjusted to meet best the conditions of placement. Under these conditions there would be a tendency to work always toward the most economical mix—that is, in the direction of increased amount of coarse aggregate. In this there would be little danger of going beyond the point where the saving in materials was offset by the additional cost of placing the harsher-working mixes.

Sand Limits—There may be conditions, however, where the relative cost of the fine and coarse aggregate and the cement would be such that economy would tend toward the use of practically all fine aggregate, a result not generally desirable, as brought out below. To avoid such a contingency, some limitations to the proportion of fine aggregate in the mix can be established where it is considered necessary.

A desirable upper limit for the size of aggregates used in the concrete shown in Fig. 20 (sand graded from 0 to the No. 4 sieve and gravel graded from the No. 4 sieve to 1½-in. size) would be that the sand should not exceed the coarse aggregate in amount. For aggregates of less than 1½-in. maximum size, the upper limit to the proportion of sand would need to be increased. For aggregates ¾ in. or less in maximum size, the sand content can frequently be considerably greater than the

coarse aggregate. The grading of the aggregates and the richness of the mix affect the limits which it is desirable to fix as the maximum sand content.

In the other direction (minimum quantity of fine aggregate) the limits are more easily fixed by the requirements of placing. Too much coarse aggregate renders the mix harsh and difficult to work and tends to increase segregation; these are deficiencies easily recognized and, because of the difficulty of placing, will generally be avoided where opportunity is presented for altering the proportion of fine and coarse aggregates. Generally harsh mixes on the job are the result of arbitrary mix requirements, rarely of choice on the part of those who are actually placing the concrete.

Effect of Excessive Sand—Reference was made above to the undesirability of too large a proportion of fine aggregate in the mix. In considering this subject it must be kept in mind that some of the objections to too much fine aggregate are based on experience with fixed proportions, where an increase in fine material directly lowers the quality through the increase in the water required to produce the necessary consistency. When the subject is approached with the idea in mind of a fixed quality of the paste, it takes on an entirely new aspect, as can be seen from much of the discussion which has been brought out. Yet there are certain objections to grossly oversanded mixes, even when used with a paste of predetermined quality. Some of these may be very important in specific instances. Among the disadvantages of such mixes are the following: increased volume change, decreased weight and increased air voids.

Volume changes are discussed separately below.

TABLE V—SHRINKAGE OF CONCRETE AND MORTAR

Specimen No.	Mix by Vol.	Water-Cement Ratio Corrected for Absorption, Gal. Per Sack	Paste-Ratio by Absolute Vol. Corrected for Absorption	Slump, In.	Shrinkage, In. Per 100 Ft. 7d.–28d.	7d.–3 mo.	7d.–6 mo.
258C	1:2:4	6.75	0.251	5	0.33	0.59	0.66
260C	1:2:2	7.00	0.339	9½	0.45	0.76	0.84
259C	1:2½:3	6.76	0.269	6½	0.30	0.57	0.62
261C	1:2½:0	7.17	0.451	10½	0.25	0.91	1.22
263C	1:2:2	5.49	0.306	3½	0.30	0.66	0.76
265C	1:1:2	5.60	0.377	9½	0.38	0.82	0.91
268C	1:1:1	4.74	0.448	9½	0.32	0.83	1.07
269C	1:1:0	4.88	0.616	11	0.34	1.06	1.49
270C	1:1:0	3.87	0.587	3½	0.36	0.88	1.24
272C	1:0:0	4.00	1.00	10	0.60	1.51	2.23

TABLE VI—SHRINKAGE OF CONCRETE OF CONSTANT-WATER-CEMENT RATIO AND VARIABLE GRADING

Water-cement ratio = 6.6 gal. per sack, corrected for absorption. Nominal mix = 1:2:3½ by volume, unless otherwise noted. Shrinkage shown is for 358 days in ordinary air following 7 days of moist curing.

Specimen No.	Aggregate: Fine	Aggregate: Coarse	Paste-Ratio by Absolute Vol., Corrected for Absorption	Slump, In.	Shrinkage, In. Per 100 Ft.
278A	0–No. 4	¼–¾ in.	0.275	7.50	0.620
280A	0–No. 4	No. 4–¾ in.	0.270	5.50	0.627
282A	0–No. 14	¼–¾ in.	0.282	6.10	0.714
283A	0–No. 14	¼–1½ in.	0.282	6.25	0.689
284A	0–No. 14	No. 4–¾ in.	0.275	1.00	0.683
285A	0–No. 4	No. 4–1½ in. *c*	0.266	7.50	0.591
286A	0–No. 14	No. 4–1½ in. *c*	0.272	7.50	0.657
287A	0–No. 4	No. 4–1½ in. *d*	0.266	8.00	0.614
288A	0–No. 14	No. 4–1½ in. *d*	0.272	6.25	0.713
289A*a*	0–No. 4*b*	No. 4–1½ in. *c*	0.251	0.25	0.587
290A*a*	0–No. 4*b*	No. 4–1½ in. *d*	0.251	4.50	0.522

a Mix = 1:2.45:3.48.
b Intermediate size (between sieves No. 28 and No. 8) omitted.
c Graded (by wt.): 25 per cent, No. 4–¼ in.; 50 per cent, ¼–½ in.; 25 per cent, ½–1½ in.
d Graded (by wt.): 25 per cent, No. 4–¼ in.; 25 per cent, ¼–½ in.; 50 per cent, ½–1½ in.

Reduced weight due to the higher paste content of grossly oversanded mixes may be of considerable importance in gravity dams or other places where weight is required. Air voids are of principal significance in connection with the reduced weight. The lower weight in oversanded mixes is due to both increased paste content and increased air voids. The proportions to use for any given set of materials to meet definite weight requirements can be determined by trial mixes with different proportions of fine and coarse aggregates mixed with the paste of required quality.

Effect on Volume Changes—The possible increase in volume change resulting from an excess of fine aggregate is probably the most important objection that can be raised to mixes of the oversanded type for ordinary construction requirements. In Tables V and VI, taken from tests by M. B. Lagaard and S. W. Benham at the Portland Cement Association Research Laboratory, are presented data on volume changes that will aid in fixing the limits of fine material in design of concrete mixes to meet specific requirements.

These data show the range in shrinkage which may be expected for various mixes and gradings for exposure in ordinary inside air for different periods of time. The specimens used in these tests were kept wet for 7 days before exposure to the air. The shrinkage shown, which is expressed in inches per 100 ft., represents the total change in length from the moist condition at 7 days to the age indicated.

The data in Tables V and VI do not lend themselves to an easy general interpretation. It will be seen, however, that the principal factor influencing shrinkage is the amount of the paste in a unit volume of concrete. This is shown in the fourth columns of the tables, the paste ratio being the volume of the paste in terms of the volume of the concrete. The water ratio of the paste is also seen to have some effect on the volume change. The influence of these two factors cannot be entirely separated, for any change in water ratio results in a corresponding change in paste volume; this accounts for the fact that rich mixes do not show volume changes as greatly in excess of those for lean mixes as might be expected from the difference in cement content—the lower water ratios of the rich mixes act to offset in quantity of paste the extra quantity of cement.

In considering the volume changes shown in Tables V and VI it should be remembered that the values for the later period are for almost complete drying out. The fact that the tests were on small specimens (mostly beams 4½x5x19 in.) must also be kept in mind, as the size of the member affects the shrinkage through its effect on the rate and extent of drying. For ordinary building structures fully inclosed, values closely approaching those found by the tests may be reached, but for outdoor structures the shrinkage would be very much less for the several mixes. In very large structures exposed to both wet and dry periods the maximum shrinkage from the original length may never be even as great as the values shown for the 7- to 28-day period in Table V, owing to the fact that no opportunity is presented for extensive drying out of the large mass.

Practical Conclusions—From the data presented it can be seen that, for special cases where volume changes must be kept at a minimum, the greatest importance attaches to the amount of paste in a unit volume of concrete. For such cases, therefore, the quantity of fine material should be kept as low as is consistent with proper workability. Sands containing large percentages

of very fine material are especially to be avoided, as they require larger quantities of paste for the same water ratio and workability and therefore increase the shrinkage.

However, for the usual structure, where there is no special demand for minimum volume change, it can be seen from these data that a reasonable latitude is afforded in the proportions of fine to coarse aggregate without greatly affecting the volume change. For example, in Table V a comparison of the 1:2:4 and 1:2:2 mixes of about the same water-cement ratio shows only about 25 per cent difference in shrinkage. This range in sand ratio is about as wide as need be required to realize the fullest possibilities of workability and economy. Intermediate mixes in this range would give differences in volume change proportionately less. With even a 25 per cent difference in volume change, no difference in design is required except where the greatest refinement in the spacing of joints is attempted. Even for such refinement, if warranted, the only effect would be to require five contraction joints where four might have been used. Where some provision is made for volume changes on any reasonable basis, it is quite unlikely that 25 per cent variations from that basis would produce noticeable defects in ordinary construction. It is where no provisions at all are made that these volume changes give difficulty.

Interrelation of Mix, Water-Cement Ratio, Cement Factor and Consistency

The interrelation of the four factors—mix, water-cement ratio, cement factor and consistency—is presented in useful form by the diagrams of Figs. 21 and 22. These are reproduced from a paper by W. R. Johnson and the writer in the report of the director of research of the Portland Cement Association, November, 1928. They show the results of a very extensive series of tests of concrete made from two different aggregate combinations (Elgin sand and gravel, and Elgin sand and Chicago limestone) in which the mixes and water-cement ratios were varied over a considerable range. The sand was graded from 0 to the No. 4 sieve, and the coarse aggregate between the No. 4 sieve and 1½ in. In these diagrams the water-cement ratios have been corrected for absorption of aggregates.

Before pointing out some of the features of these diagrams attention is called to the fact that the curves are not for general application, as they are based on these two materials only. Materials of other size, grading or surface characteristics would not show the same quantities of cement or the same slump for the given mixes and water ratios. The curves are useful, however, in establishing certain general relationships which would be similar with other materials. Like sets of curves drawn for several different types of materials would serve as a very good guide for general use in designing mixtures for materials of similar types.

It will be noted that Fig. 21 shows four sets of curves, two for each kind of aggregate for the two water-cement ratios of 5 and 6 gal. per sack. The groups are arranged for easy study and comparison. Fig. 22 shows similar curves for water-cement ratios of 7 and 8 gal. per sack. The mixes shown are expressed in the common manner: 1 cement, x sand, and y coarse aggregate, except that the volumes are on the basis of dry, compact materials. For each family of mixes and each water ratio in these diagrams a single curve shows the change in cement quantity (sacks per cubic yard of concrete) and consistency (slump), as the amount of coarse aggregate is changed within the given mortar family.

One feature of the diagrams of Figs. 21 and 22 that should be emphasized is the relative position of the curves for the different families for each water ratio. It will be noted that the curve for one family of mixes occupies a position on the diagram lower than that for any other family, but that no one family is the lowest in the several groups representing the different water ratios. In general, either the curve occupying the lowest position, or the one immediately above it, contains (within the range of slumps from about 2 in. to 6 in.) the mixes for that family in which the ratio of fine to coarse aggregate is not greater than 1:1 or less than 1:2. Within this range of slumps also the grossly oversanded mixes are high in cement factor. Thus the mixes which are the more desirable in the light of the other considerations which have been discussed—shrinkage, weight, etc.—are seen to be among those comparatively low in cement factor. This bears out the point made in the discussion that when working with a fixed water-cement ratio the

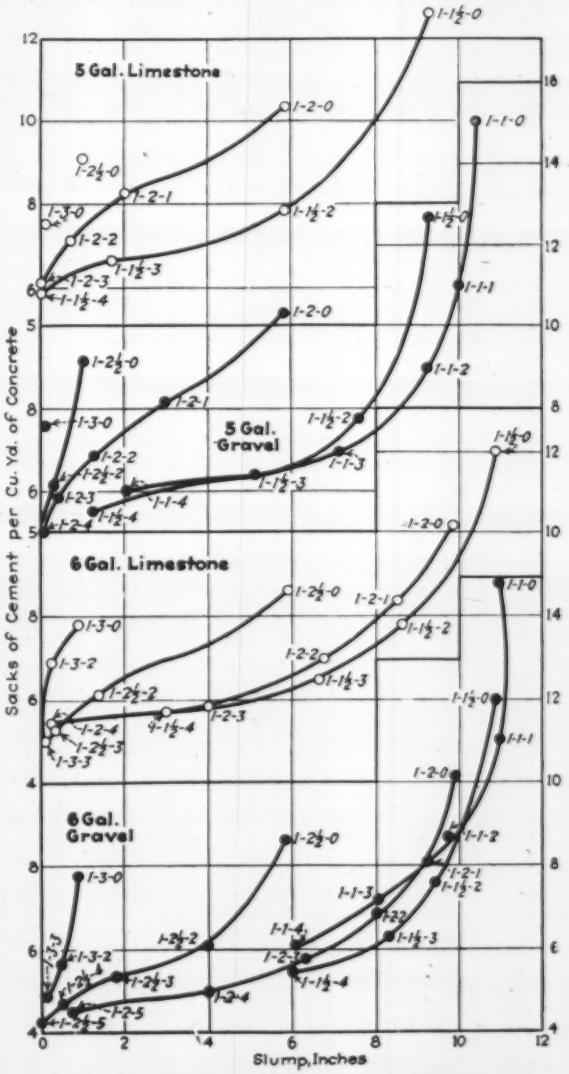


FIG. 21—INTERRELATION OF MIX, WATER RATIO, CEMENT FACTOR AND SLUMP

These curves are for these materials only. Other materials will not give the same cement factor and slump for corresponding mixes and water-cement ratios.

natural tendency to avoid non-workable mixes on the one hand, and mixes high in cement factor on the other, would lead to the use of mixes most desirable from other considerations.

Fixed Cement-Sand Ratio—In the light of what has just been brought out it is of interest to consider the suggestion that has sometimes been made of applying water-ratio control by the use of a 1:2 mortar with a fixed water ratio, allowing workability to be adjusted by merely changing the coarse aggregate quantity. It can be seen from Figs. 21 and 22 that such a method, while entirely practicable, would certainly result in loss of economy for some water ratios and materials. For example, in the 5-gal. mixes of Fig. 21, the 1:2 mortar is certainly not the most desirable. Likewise, for the other water ratios, intermediate families like the $1:1\frac{3}{4}$ or the $1:2\frac{1}{4}$ might easily show an advantage. differences in sands would also have an influence on the economical cement-sand ratios. The better method is to leave the aggregate proportions as wide open as possible, fixing only those limits which are necessary to insure proper workability and to avoid extremes in unit weight or cement factor.

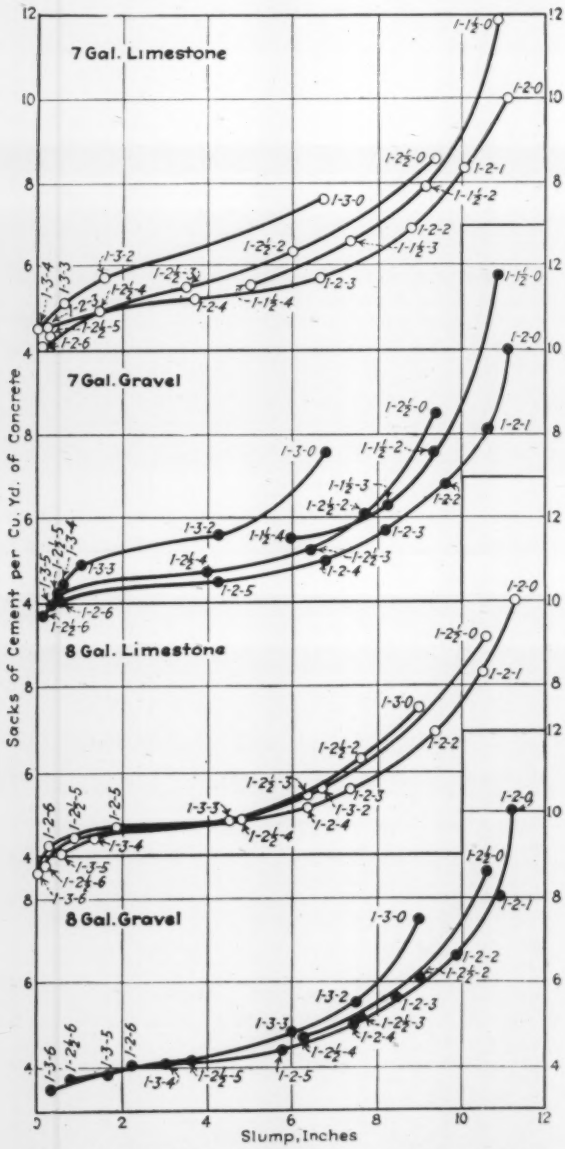


FIG. 22—INTERRELATION OF MIX, WATER RATIO, CEMENT FACTOR AND SLUMP

These curves are for these materials only. Other materials will not give the same cement factor and slump for corresponding mixes and water-cement ratios.

Overwet Mixes—Figs. 21 and 22 show very clearly the great disadvantage of the overwet mixes. With the water-cement ratios fixed, it is seen that for slumps much above 6 in. the cement factor increases very rapidly for additional slump. This is one of the factors that can be depended upon to prevent extremely wet mixes where the water-cement ratio is to be fixed. Constructors who formerly felt the need of a very wet concrete will respond rather quickly to the suggestion for less fluid mixes when it is seen that a change from a 9- to a 6-in. slump, for example, means the saving of more than one sack of cement per cubic yard.

These curves also show that the saving in cement by the use of very dry or harsh mixes is very small and will not at all compensate for the extra cost of placing. It is interesting to note that for most of the diagrams the range in slump of from 2 to 6 in. embraces portions of the curves that are nearly horizontal. This shows that within this range the best control of consistency can be exercised with little or no change in cement factor.

Summary of Grading Principles

This discussion has shown that there is no fixed schedule of gradings or combinations of fine and coarse aggregate that can be set up as essential to good concrete construction or that is notably superior to many other combinations. The essential requirement is that, for a paste of given quality, the aggregate combination be such that the concrete can be placed properly and that it will not segregate either in placing or after it is in place. All the space between the aggregate particles must remain filled with the paste of desired quality.

It requires no elaborate theory of mixtures or cumbersome calculations to find aggregate combinations that will meet these requirements. The range within which they can be met without exceeding safe or sane limits in the cement quantity is wide enough to allow for considerable variations in materials and ample opportunities for economy. Any of the available materials that have been proved suitable as to cleanness, strength and durability can be utilized to their best advantage. Some restriction must be put (1) on the proportions of fine aggregate, to avoid mixes with high shrinkage factor, and (2) on the workability, to prevent an attempt to place mixes that are bound to result in honeycomb and stone pockets.

The best method of finding the most suitable proportions is by trial. A number of mixes using paste of the required water ratio can readily be made up in which the quantities of materials and the yield can be measured and notes made of the workability. From the results of these trials the mix best suited to the particular job can be selected. These trials can be by small batches or in full-sized batches in the mixer. In any case the water-cement ratios used should take into account the absorption, if dry aggregates are used, or the free water, if any, carried by the aggregate.

Before leaving the matter of selection of the proportions it should again be emphasized that this is only one step in the production of successful concrete structures. Selection of the proper water-cement ratio, control of the consistency to avoid segregation or accumulation of water at the top of a section, control of the curing of the finished product, properly made construction joints,

and durable aggregates, are vastly more important to the life of a structure exposed to weathering than any possible improvements resulting from ordinary changes in proportions of materials or grading.

Further Improvement in Concrete Practice

The discussions of Fig. 1 in the first article and of Fig. 20 of the present article have shown certain limitations in the present methods of making concrete and point the way to any major improvements which may be made in concrete practice. In the discussions of these figures it was brought out that, regardless of the aggregate combinations or quantity of cement, a certain amount of water per unit volume of concrete will remain in the mass in a more or less uncombined state. This extra water is required to give mobility to the mass in order to make it possible to place the concrete and give a homogeneous structure. Grading can do but little to improve this condition, as shown by a study of Figs. 1 and 20 and the discussion of this article. At best, only a bare 5 per cent of the concrete volume in plastic mixtures can be changed from water into solid material by improvements in grading over what is ordinarily accomplished. This leaves from 8 to 12 per cent of water, as shown in the figures. It is toward the reduction of this quantity of water that any proposed improvements must be directed.

By using richer mixes the proportion of the uncombined water in the paste is reduced to the point where the paste becomes watertight to almost any desired degree, even though the total water per unit volume of concrete is not materially lowered. But extremely rich mixes are undesirable, so the opportunities for major improvement must be sought elsewhere than in matters of grading or richness of the mix.

Better Curing—Improved curing to force more and more of the water into the permanent solids of the mass has been emphasized. This is important, and the test data quoted, as well as experience, have shown that it offers the greatest single opportunity for better concrete under our present methods.

Obviously there is a limit to the amount of water that can be combined with a given quantity of cement, so that complete exclusion of uncombined water from the concrete is not possible by extended curing. In this connection it may not be amiss to suggest to those who are looking for a panacea in the form of some new cement that these same limitations will still exist if the concrete is to be placed in a plastic condition. Either extra quantities of the cement must be used to combine with all the water or uncombined water will exist in the mass.

Methods of Placing and Treatment—These comments suggest the other lines along which improvement can be made. These are two—namely, first, *the removal of excess water after the concrete is in place,* at the same time consolidating the mass; and second, the placing of concrete by some method *that will insure* without the use of extra water *the same degree of consolidation, the same complete filling of the mass with the cement paste,* that is obtained with the plastic mixtures. There are good examples where both of these methods have been used successfully, but neither has been developed for general application to the degree that its merit warrants.

It is not the purpose here to elaborate on the possibilities of these methods of placing concrete, but only to point out that results in full accord with the fundamental principles of this series of discussions can be expected from them. It can be readily seen that any method of placing which extracts water from the mix as it is being deposited, in such manner that the space occupied by this water is at once filled by the consolidated concrete, accomplishes the desired end. In such a method the advantage of plastic mixes in mixing and handling is retained, while the disadvantage of the large proportion of uncombined water is eliminated.

The use of an absorptive sand mold in the making of cast stone is a common illustration of this method. Probably the most notable illustration is the work of John J. Early in placing concrete in the "Fountain of Time" at Chicago ("Building the 'Fountain of Time,'" by John J. Early, *Proc.*, Am. Concrete Inst., Vol. 19, p. 185, 1923). The Bruner patented method of placing floor finish is still another illustration.

Placing concrete with less water than is required for plastic mixtures was long practiced, and many examples of early structures in excellent condition today bear evidence of the possibilities of the method. In these structures fairly lean mixtures were placed in thin layers in semi-dry condition and thoroughly rammed until water flushed to the surface. This flushing of water to the surface as a result of the ramming was evidence that the space between the aggregate particles was thoroughly filled with the paste. The paste was of high quality because of its low water ratio, which accounts for the excellent condition of many of these old structures. The patchy appearance of some of the structures shows the difficulty of always getting proper ramming and thorough bonding of successive layers.

The purpose of these comments is not to advocate the return to this method of placing, but to suggest that mixes too stiff for plastic consistency might be placed successfully by some mechanical means. The requirements for such a method are easily visualized from this discussion. The net result of the operation must be a mass in which the spaces between the aggregate particles are everywhere filled with the paste of desired water ratio. Thus, by starting out with a mixture in which the quantity of paste is insufficient to give a plastic mass, the space between the aggregate particles is so reduced by mechanical means that finally it is completely filled by the paste.

In all of these methods the proportioning of the aggregates can readily be done by trial mixtures using a paste of the desired water ratio, just as in the case of mixtures to be placed in a plastic condition. Under these suggested methods of placing, if the aggregates are finally completely incorporated in the paste, the properties of the concrete will be principally measured by the properties of the paste just as in the case of plastic mixtures.

In the fourth and fifth articles of this series consideration will be given to some of the details involved in carrying out construction projects along the lines of these basic principles.

Mr. McMillan's fourth article will appear May 2.

New Scaffolding Regulations in Montreal

New regulations obliging inspection of all scaffolding used by public and private contractors and builders are now in force in Montreal. The law demands that before erecting any scaffolding or elevator a permit from the city public works department must be obtained and before such scaffolding or elevators can be used the city inspectors must issue a certificate of inspection.

Legally Safe for New York to Divert Delaware River

Hughes and Davis Hold U. S. Supreme Court Unlikely to Bar Diversion of Interstate Stream for Water Supply

ASSURANCE that the city of New York has legal right to take the floodwaters of certain tributaries of the Delaware River wholly within the State of New York for an additional water supply are given in opinions by Charles E. Hughes and John W. Davis made public April 17 by the Board of Water Supply of that city. The opinions, which are independent, agree in essentials. They center in holding that, providing proper provision is made for the right of riparian owners and other parties in interest, the Supreme Court of the United States is not likely to enjoin New York City from going to the New York tributaries of the Delaware for water.

The Delaware River project was outlined in a report of the Board of Water Supply and its chief engineer, Thaddeus W. Merriman, dated July 27, 1927 (see abstract, with map and profile, *Engineering News-Record*, Aug. 11, 127, p. 218). It provides for a water supply averaging 600 m.g.d. from (1) floodwaters of five tributaries of the Delaware River and (2) of 100 m.g.d. from Rondout Creek, a tributary of the Hudson, with necessary impounding reservoirs and aqueducts, at an estimated cost of $273,000,000. Above Tristate Rock, approximately where New York, New Jersey and Pennsylvania corner in, the Delaware River has a drainage of 3,415 square miles, of which 2,389 are in New York, 1,016 in Pennsylvania and only 10 in New Jersey. Of the 115 miles of river length above Tristate Rock, the first 55 are in New York State, leaving 60 miles along the boundary. Below Tristate Rock, the Delaware lies between Pennsylvania and New Jersey.

Two Attempts at Allocation Fail

Two attempts to effect an allocation of the waters in question by means of a tri-state compact have failed after agreement among commissions created by each state for the purpose, assisted by engineers and lawyers, the New York Legislature alone ratifying the compact. (For the main points in the two compacts, see *Engineering News-Record*, Feb. 5, 1925, p. 233, and Jan. 20, 1927, p. 130.) The terms of the second compact, in which an attempt was made to meet objections by New Jersey and Pennsylvania to the first one, is followed by the engineers of the Board of Water Supply in their diversion plan. Both the compact and the plan provide for releasing stored water (1) to the upper basin at the rate of 0.45 sec.-ft. per square mile of drainage area above each point of storage during July, August, September and October and on any and every day in other months when the yield above the point of storage is less than the amount named; and (2) to the lower basin 0.15 sec.-ft. pr square mile of drainage area above the point of storage. This, it is held, would insure and increase the low-water flow of the river. Threats of legal action by New Jersey and Pennsylvania to prevent New York City from carrying out its Delaware River project on the ground that the people of those states have the right to the undiminished flow of the river led the Board of Water Supply to engage Messrs. Hughes and Davis to give the opinions made public April 17.

Inasmuch as both opinions traverse much the same ground and are in agreement, and since Mr. Hughes' report is more detailed than that of Mr. Davis, chief attention will be given to the Hughes opinion.

Will Not Affect Navigation

In the light of the U. S. Supreme Court decision in the Chicago Drainage Canal case (Wisconsin vs. Illinois, Jan. 14, 1929; see *Engineering News-Record*, Jan. 24, 1929, p. 146), Mr. Hughes states: "Whether Congress has power to provide for the diversion of navigable waters from one watershed to another is a question which may be regarded as not yet finally determined." He goes on to say that if "Congress has this power it would be exercised only in the interest of interstate commerce—that is, navigation." Similarly, the Secretary of War could act in the present case only to protect navigation. Therefore, unless the proposed diversion would injuriously affect navigation "the United States will not be entitled to complain." Mr. Hughes seems to accept the evidence before him to the effect that the diversion would not affect navigation.

The larger part of Mr. Hughes' opinion relates to "the interests of the states of Pennsylvania and New Jersey." These center in possible claims of injurious effects of the proposed diversion on navigation and on "the beneficial uses of interstate streams" aside from navigation. On both these Mr. Hughes holds that the states have a right to invoke "the protection of the federal government," but he gives no further consideration to possible injury to navigation.

Rights of States Outlined

The two outstanding U. S. Supreme Court cases dealing with controversies over interstate waters (Kansas vs. Colorado and Wyoming vs. Colorado) are not conclusive as regards the Delaware River problem, partly because Colorado, a party to each case, had adopted the rule of prior appropriations and partly because of other local conditions. All three of the states concerned with the Delaware follow the common law riparian rights doctrine. Each has also built up, through the years, a working plan of permitting the taking of water for public purposes to the detriment of lower riparian owners, although not without compensation. But as between states, each, says Mr. Hughes, "is on a footing of equality with every other state," and as a last resort must go to the federal courts. When the Supreme Court becomes the arbiter, says Mr. Hughes, there must be "an equitable division of the waters of the interstate stream" in question, taking into account "the uses and present and future needs of each state, and the extent of and circumstances of any proposed diversion," and also providing reasonable compensation to those below when water is taken for the benefit of those above a state line.

In the absence of a "decision of the Supreme Court of the United States directly in point," Mr. Hughes can give "no assurance" of what the court would decide if there were a suit "between the states over the execution of the plan proposed by New York." Further on he gives weight to the compacts agreed on by the three commissions and ratified by New York but not by the two other states, and then sums up:

> The compacts which have been made by the three states are admittedly ineffective, but the concurrence of the commissioners of the three states, and of all their legal and technical advisers, gives strong support to the views expressed in the papers submitted by the Board of Water Supply. The ultimate decision, in my judgment, would be controlled by the findings of fact which

would be reached after these statements had been attacked and defended in a contested case.

I may sum up my conclusions as follows:

I have no doubt that the court would insure the protection of the interests of navigation.

If it were found that the statements in the papers submitted were mistaken and that the proposed plan would result in irreparable injury to either Pennsylvania or New Jersey—that is, an injury which could not be averted by enforcing practicable restrictions or be suitably compensated—I am of the opinion that the Supreme Court would enjoin the diversion.

If it appeared that there might be serious injury to either of these states or their inhabitants which could be prevented by the imposition of restrictions and conditions, I am of the opinion that the Supreme Court would enjoin the diversion unless there were compliance with such restrictions and conditions suitably defined. But if it were found that the diversion according to the proposed plan could be made with restrictions and conditions which would adequately protect the interests of the complaining states, upon the basis of an equitable division of the waters in question with reference to the aggregate interests of each of the three states, respectively, and subject to the payment of compensation for such damages as might be suffered by individuals, I am of the opinion that the diversion should not be enjoined and that the relief to the complaining states should be limited to the definition of enforcement of restrictions and conditions prescribed for the above purposes.

Mr. Davis' Opinion

Mr. Davis, at the close of opinion, gives weight to the tri-state compacts and to the following statement by Thaddeus Merriman, chief engineer of the Board of Water Supply of New York City: "Were it possible to put the proposed plan into operation without the knowledge of any person along the Delaware channel, no claim for damage would ever be presented." In conclusion Mr. Davis expresses the belief that unless some "new doctrine is enunciated meanwhile by the U. S. Supreme Court "neither New Jersey nor Pennsylvania can successfully maintain a suit in that court to prevent the carrying out, under authority of the New York Legislature, of the proposed plan as disclosed by the documents submitted."

Department of Agriculture to Make Extensive Studies of Soil Erosion

RAPID progress is being made on the preliminaries of an extensive study of soil erosion under the direction of S. H. McCrory, chief of the division of agricultural engineering, U. S. Bureau of Public Roads. In the Department of Agriculture appropriation act an item of $160,000 was included for an investigation of the causes of erosion, the possibility of increasing the absorption of rainfall by the soil in arid regions, the conservation of rainfall by terracing and other means, the prevention of erosion and related problems. Mr. McCrory points out that too little is known about the soil of this country, which many term the most important of all natural resources. The historical importance of soil conservation is seen in the generally accepted theory that soil depletion was one of the primary causes for the downfall of Roman civilization.

AIR PHOTO SHOWING TYPICAL EROSION CONDITIONS AT THE GUTHRIE, OKLA., FARM

The forthcoming studies will provide basic data not only for agricultural conservation but for strictly engineering problems such as reservoir siltage, riverbank scour and the washing of earthworks. For this purpose a farm has been acquired near Guthrie, Okla., where the surface erosion, as shown in the accompanying illustration is typical of many parts of the United States. Arrangements are being made for the lease of a second farm in Texas. The Bureau of Public Roads, the Bureau of Soils and Chemistry and the Forest Service will co-operate in the main investigation. Experiments are to be made with terracing, underdrainage, soil-saving dams, cover crops and such other means of erosion control as may develop.

The nature of the results to be gained may be judged from reports of the North Carolina Experiment Station, which has been working on soil problems for the past three years. One surprising development was that the erosion from an area planted in cotton was 355 times as great as on a similar area of grass sod and that the run-off was 23 times as great.

Value of Coatings to Prevent Corrosion of Underground Pipes Investigated

The destruction of buried pipes and fittings through soil corrosion is a source of heavy expense in many industries. Moisture is necessary for corrosion, and the U. S. Department of Commerce points out that any coating which prevents moisture from reaching the pipe is satisfactory from a corrosion standpoint regardless of its thickness, adhesion or other properties usually specified. To be worth while it must be practicable to apply the coating in a commercial way and its cost must be less than the value of the life added to the line. To decide whether a coating will pay it is necessary to know the cost of the coating applied, the life of the line if it is not coated and the time that the coating will protect the line.

Methods for determining the corrosiveness of soils are being developed at the Bureau of Standards and elsewhere, but their value is still somewhat in doubt. Field inspections to determine the life of coatings are frequently unsatisfactory because of failure of inspectors to agree as to the condition of the coating and because the specifications for the coating, the manner of its application, and the condition of the pipe at the time the coating was applied cannot be learned. Accelerated tests which involve conditions not encountered in the field are of doubtful value. Sensitive tests which show incipient failure of coatings are in some ways more satisfactory, and for this reason a test which indicates whether a bituminous coating has allowed moisture to reach the pipe has been developed by the bureau.

Correction

In the article, "Chlorination Relieves Ponding on Sewage Filter Beds," by Frederick K. Wing and Roger C. Williams, appearing in our issue of April 18, the address of the Frederick K. Wing Company was given incorrectly as Rochester, N. Y. It should have been Buffalo, N. Y.

An Estimate of Tower Machines for Mississippi Levee Construction

Span Limits for Tower Machine for Levee Building Are Not Reached—Methods of Extending Reach for Borrow —Contract Work Operation Labors Under No Handicap

By W. L. Thompson
Consulting Engineer, Starkville, Miss.

THE WRITER of this article speaks with the authority of long experience on Mississippi River work. Beginning work with the Mississippi State Levee Board soon after graduation in 1897 he rose to the position of assistant engineer. In 1905 he took a position on the engineering staff of the Panama Canal, from which he resigned as assistant engineer in 1913 to become chief engineer of the levee board, where he had much to do with developing the tower machine which he analyzes so trenchantly in the following article. Mr. Thompson was afterward in consulting practice for several years, until early in 1925, when he became engineer-superintendent for the Indo-Burma Petroleum Company on its flood-control work on the Irrawaddy River. This engagement was completed in the fall of 1928. —EDITOR.

IS SELECTION of materials for Mississippi levees worth particular effort from an engineering economic viewpoint? Does the tower machine for building levees approach in its present span length the limit of economic reach? Is the contractor under a handicap in the operation of tower machines in competition with the district engineer forces, which have heretofore been the chief users? In general, an affirmative answer is indicated in the recent articles by C. S. Hill on Mississippi Flood Control (*Engineering News-Record*, Jan. 17, 24 and 31). Such a conclusion is decidedly not in accord with the writer's long experience on the river work.

Selection of Material—Levees built according to specifications heretofore—that is, with borrow opposite—have not in the causes of failure indicated the need of any such general practice. Selection means greatly increased haul and the exclusion perhaps of a highly efficient one-unit plant for a less efficient multiple-unit plant.

There will be, in the future as in the past, a few spots easily recognized where local selection is in order. Also as in the past, such spots are too few and isolated to be considered in the general treatment. Along the levees generally the nearest available material is about equal in quality to any other material in that vicinity. Any real general selection would probably more than double the cost. The indicated need of such selection would not justify a 5 per cent increase in cost.

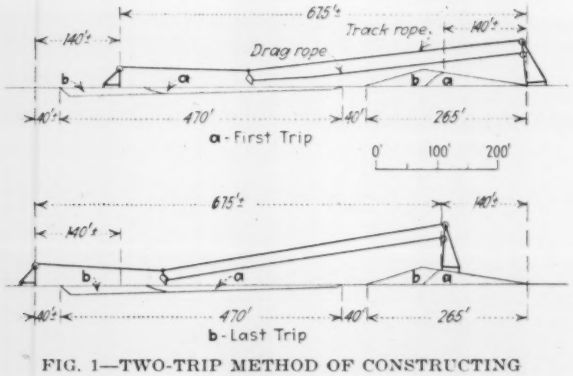


FIG. 1—TWO-TRIP METHOD OF CONSTRUCTING NEW LEVEE

Economic Span of Tower Machines—It is said: "The year's experience and observation seem to have pretty well dissipated the notion that the device [tower machine] could be enlarged to extend its economical reach for embankment material," with the maximum span given as 600 ft. Cost of course increases with the span, and there is at some point an economical limit as compared with other methods. At some point there is also a feasibility limit without reference to cost. Whether these limit points coincide or not, they are both much beyond 600 ft. If the tower machine is "a close runner-up to the dragline in economy" up to a span of 600 ft., it must and does continue at considerably longer spans to be more economical than any possible loose-motion, longer-haul method. There is no abrupt break in the cost curve at 600 ft.

These tower machines are designed for a nominal span of 650 ft. with 5- and 6-cu.yd. buckets, but with safety factors for heavy overload and for a materially longer span. About 1921 one using a 5-yd. bucket was operated successfully on a span of 800 ft. in the construction of a new levee near Perthshire, Miss. This does not indicate that even 800 ft. is a limit; it is only the limit for a 5-yd. bucket of the kind used. A 4½-yd. bucket would have a still greater limit. Nearly all past work using a 6-yd. bucket has been with a span around 500 ft., that being usually sufficient for reaching enough new material back of the old team pits.

A new levee section running 13,000 cu.yd. per 100 ft. in "loam" would have a height of 25.5 ft., a pit width of 470 ft., a base of 265 ft. and a (constant) berm of 40 ft., or an over-all width of 775 ft. Just as heretofore it would be built in two trips, building the base well up in the land side portion on the first trip so as to serve as a roadbed for the head tower on the second trip. This first trip fill can readily provide such a roadbed 100 to 150 ft. nearer the borrow. By simply running the tail tower that amount closer in on the first trip than it requires to be on the second, the maximum span would not exceed 700 ft. on either trip.

This second trip on new levee construction is essentially the same as the one-trip process of enlargement work. The total of old pit section and required new pit section is not greater than the total pit section required for a new levee. It is, in fact, usually an appreciable amount less because of years of silt deposit in and back of old pits. Thus a span of about 700 ft. would be generally sufficient for future enlargement work, and in any localities requiring a longer span no reduction of bucket capacity would be needed much short of 800 ft.

Adaptability to Conditions—Fig. 1 shows a two-trip method of constructing a new levee of the above dimensions. It is seen that the span for a levee of this size need not exceed 675 ft., or about 125 ft. less than the actual permissible span with a 5-yd. bucket of the present type. Extreme cases where the maximum permissible span would not be sufficient would be too rare for consideration in a general construction method. In such cases, however, enough can be placed in the land side part of the section by teams or other means to enable ready completion with two machine trips.

Fig. 2 shows how the new levee section may be adapted to the section of the old levee in enlargement work. In this case the existing levee is of the past standard section, 23 ft. high, with enlargement to the new proposed section 25.5 ft. high. Where the top of the head tower is not enough above the top of the tail tower to permit a ready gravity return of the empty bucket, a rehaul line (not shown) is put into use. Gravity is ample for most enlargement work. The rehaul line is usually needed on the first trip of new levee construction. It should be taken off where gravity is sufficient, as it then slows up operation.

Possibilities of Tower Machine Improvement—If these machines are uneconomical or unable to do the work operating as single units, they should be scrapped. If the material must be rehandled, it might as well be conveyed to within reach of a more efficient rehandling unit, and the revolving dragline is without a rival for work within its radius. If these machines can do the work efficiently as single units, many more of them would seem to be called for. In additional machines, it is reasonable to assume that further improvement could be made.

A new type of bucket has been recently tested on a machine in the Memphis district with promising results. The makers claim that it has converted the 5-yd. machine into an 8-yd. machine. There are other types of bucket and scrapers which have been in existence for many years and which still deserve exhaustive trial.

Contract Operation of Tower Machines—The assumption that tower machines can be most economically operated by the district engineers seems to be at least premature. The work is ideal for contracting in the definiteness of conditions and quantities. There has been no competition by contractors for the reason that contract levee work has been restricted to one year or one season. There can be no such competition on short-time work unless government machines should be farmed out to contracts on a rental basis, a plan that would have its possibilities even on a large scale.

The fact that there are going organizations and certain repair facilities in the districts is not sufficient reason for the exclusion of competing contract operation of tower machines. Nor does it follow that costs have been or would be less than for less well-equipped contract operation. Contract operation should not be merely made possible; it should be encouraged.

There is no mystery about either maintenance or operation which is beyond the ready reach of any intelligent man who is acquainted with general construction equipment. A safe supply of spare parts can be stocked by a new organization as well as by an old one. New organizations formed now would shortly be old organizations, and the work will run for a long time. There are commercial machine shops and foundries along the river which can be reached quickly from any point by motor truck, motor boat, steamer, train or perhaps air. Any extension of facilities to contract operators by the districts even under a scale of profitable charges would be reflected in more confident bidding and lower prices.

There is another point too important to omit, since on it hangs perhaps the whole matter of successful machine contracting, even though all other serious difficulties are cleared away. The machine bidder must know that he can move his machine or machines from the site of one contract to the site of the next one, even if across the river and hundreds of miles away.

The machines are readily propelled onto barges at the riverbank at moderate to bankfull stages. The contractor must rent suitable barges and towboats, or he must buy them. Barges bought would be available for many moves and for a long time. In this way the moving can be assured and the cost per move brought to only a few thousand dollars at most. Several contractors might pool, or form a subsidiary machine transfer company and make the venture self-supporting as a common carrier service for machine transfers to the end of the work. But a still better plan would be for the district engineers to co-operate in assuring an interdistrict transfer service (with appropriate charges) to levee-building equipment wanting it from any point on the river to the site of any levee contract.

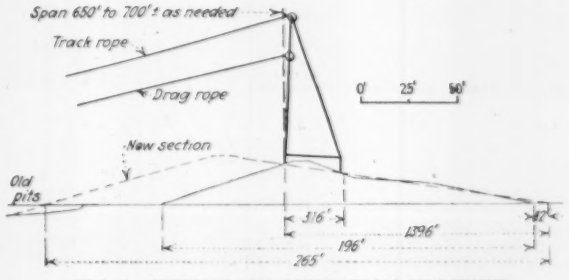


FIG. 2—METHOD OF OPERATION IN LEVEE ENLARGEMENT

Conclusion—The writer believes with many others that work should be done by contract as far as possible; and that the usual advantages of contract work are lower cost, better quality and less time, or some of these. The one-unit tower machine was mothered by the necessity for getting away from multiple units and the rehandling of material. It is the only one-unit levee building equipment possible.

Ozone Disinfects Filtered Water at Delhi, N. Y.

Effluent from a mechanical water-filtration plant at Delhi, N. Y., is disinfected by ozone. The purification plant was built recently at a cost of about $42,000 as a result of recommendations of the Division of Sanitation of the New York Department of Health. According to *Health News*, the official organ of the New York State Department of Health, "the ozone installation at Delhi is the first in New York State to be used for disinfection of a public water supply," and as far as known it is the second in the United States, although the use of ozone for this purpose is "fairly common in some of the larger cities in Europe." [Ozonization has been used in the United States in at least two places before the Delhi installation: at Ann Arbor, Mich., and at the plant of the Baltimore County Water & Electric Company before this plant was taken over by the city of Baltimore. Both these ozonization plants have been out of use, we understand, for a number of years.—EDITOR.]

From Job and Office

Hints That Cut Cost and Time for the Contractor and Engineer

Tractor Places Lines of 4-In. Drain Tile Without Ditching

By Herbert A. Bowers
Santa Clara, Calif.

A SIMPLE and speedy method of laying agricultural drainage systems without the necessity of digging ditches has been used successfully on irrigated land in California with considerable saving in time and cost. The scheme involves threading the tile on a manila cable just as beads are strung on a thread and then pulling a 200-ft. length of the tile underground in one operation. The scheme can be used successfully, it is believed, wherever the ground has uniform slopes that correspond with permissible grades in the lines of drain. Thus far nothing larger than 4-in. agricultural tile has been placed by this method.

The first operation is the loosening up of the ground in which the tile is to be laid. This is done with a subsoiler, a farm implement resembling a cultivator with only one tooth, which is of large size, affixed to the bottom of a vertical blade. The tooth thus runs deep in the ground, loosening the subsoil and leaving the surface undisturbed except by the passage of the thin blade.

For drain tile to be laid 2 ft. below the ground surface, a subsoiler set for a 24-in. depth is first pulled across the field on the line where the drain tile are desired, care being taken to follow a straight line between marks set up on opposite sides of the field.

The next step is a return trip across the field, a tractor hauling the subsoiler as before and following exactly the same line to gain the advantage of the previous loosening. This time there is attached to the rear end of the subsoiler an iron cone 6 in. in diameter and to this in turn is fastened the forward end of a 200-ft. length of 2½-in. manila cable on which the drain tile previously have been threaded. The rear end of the cable is fitted with an iron cap or follower, put on after the drain tile have all been threaded, the function of which is to distribute the thrust evenly on the last tile. Thus the tile themselves are really thrust forward by pressure from the rear end and are always in compression, the manila cable at once serving to guide their line of travel and to transmit motive power to the rear end of the string.

By this method and using a 30-hp. tractor mounted on crawlers, 4-in. concrete agricultural tile were successfully drawn into position in 200-ft. lengths. It is suggested that with a more powerful tractor it might be possible to combine both operations in one move, thus making unnecessary a second trip along the same line. It is necessary to have the cable of sufficient size to fill the inside of the tile; it was found that with a ½-in. wire rope in tile of 2½-in. inside diameter the individual tile sections would not remain in alignment.

When several 200-ft. lengths of tile have been pulled underground their ends are joined by hand. The short lengths of ditch necessary for this purpose are easily made with a shovel, as the ground is well broken up by the subsoiler. The jointing operation sets at the prescribed grade the tile along that length of travel ordinarily required to get the subsoiler down to grade. Jointing is facilitated by stopping the tractor just before the last tile disappears below the ground. This marks the spot and facilitates disconnecting the cap which frees the cable so that it can be withdrawn by the tractor.

With a little practice the hauling process can be halted so that successive 200-ft. lengths are in exact position and no additional tile will have to be carried along the line to complete the joints. Only a moderate amount of care is required to complete a continuous and uniform grade across the short length of the line (usually about 8 ft.) that has to be excavated by hand at each joint.

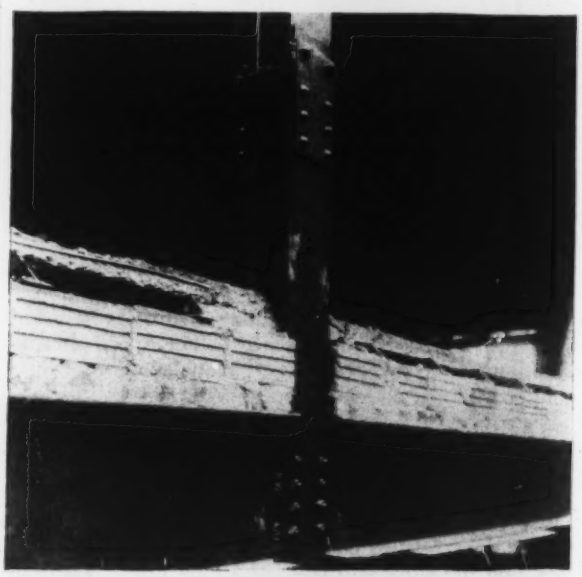
The scheme described in the foregoing would be particularly effective, it is believed, on marsh land in need of drainage, which is firm enough in the dry season to permit the use of a tractor.

Erecting Hospital Addition by Arc Welding

SEVERAL features of interest were developed in erecting by welding a shop-riveted structural steel frame comprising a quarter-million dollar addition to the Ohio Valley General Hospital in Wheeling, W. Va., according to the Lincoln Electric Company.

The present building forms three sides of a square, one side being six stories high, the two other sides five stories high. The new addition incloses a court and brings all sides of the hollow square up to a height of six stories. During the erection all members were held by steel bolts through holes punched in the shop. For the beam-to-column-flange connection ordinary clip angles were used, riveted to the columns and bolted to the beams. However, the web of the beam was butted against the flange of the column and joined by intermittent fillet welds.

Another detail of interest is given in the accompanying



TYPICAL COLUMN SPLICE AND SPANDREL CONNECTION IN WELDED HOSPITAL ADDITION
Note also the plate lintel welded to bottom of the spandrel.

illustration, showing the method of splicing the columns. About two-thirds of the length of the splice plate was fastened to the lower column section by six shop rivets, while the top third of the splice plate was punched for two field bolts which held the two sections of column in line while field welding the splice plate to the top column sections. Spandrel beams in the structure were connected to the columns by welding their webs to the inside of the column flanges, the outer flanges of the spandrel beams having been cut away. The spandrels, which were 15-in. channels, were held by three 3-in. intermittent welds. Lintels consisted of plates welded to the bottom of the spandrel beams while they were being held in place by C clamps. Bar joists welded to the floor beams were used to support the 2-in. concrete floors and roof slab.

The building was designed by Charles W. Bates, of Wheeling, and is being erected by R. R. Kitchen & Company, of Wheeling, using two portable motor-driven welders of 300-amp. capacity.

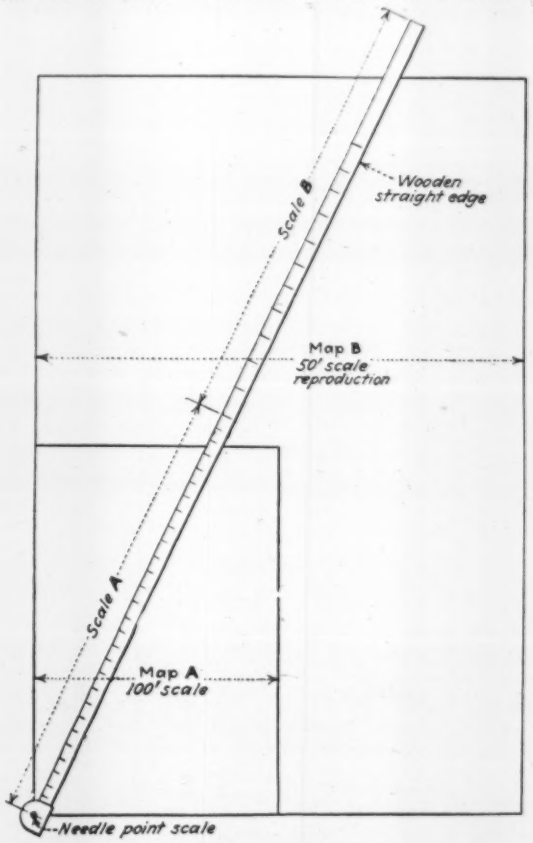
Fast and Accurate Method of Reproducing Drawings

By C. K. Clausen

Seattle, Wash.

THE attached sketch indicates a fast and accurate method of reproducing drawings or maps to an increased or diminished scale. It is more accurate than the pantograph or photographic methods and where a great deal of work on the same scales is to be done it is a time saver as well. A piece of a transparent triangle was pierced for a needle point and fastened to a wooden T-square leg in such a way that the needle-point hole came in accurate line with one edge of the T-square leg. Paper scales were glued to the straight-edge so that they read the total distance in feet to scale from the needle-point origin.

In this case a hundred scale, the scale of the small maps, was glued to the lower part of the straight-edge and a fifty scale, the desired scale of the reproductions, glued to the outer portion of the straight edge. By placing the small map in several positions on the reproduction and fixing the needle point so that similar triangles are obtained between the small map and its reproduction, any number of points on the small map can be accurately transferred to the larger scale map by scaling distances along the common hypotenuse from the needle point origin.



ACCURATE FAST METHOD OF REPRODUCING MAPS OR DRAWINGS

Old Wooden Covered Bridge With Arcaded Sidewalks

STORIES of the old covered wooden bridge builders are among the most interesting incunabula of engineering. Motoring through southern Indiana last fall, W. R. Roof, bridge engineer, Chicago Great Western Railroad Company, Chicago, Ill., became interested in

TWO-SPAN COVERED BRIDGE AT RUSHVILLE, IND.

the covered bridges, "twelve or fifteen of them," which he crossed, and he made inquiries. One of these bridges, at Rushville, Ind., on account of the colonnaded sidewalks attracted his attention particularly. In searching for the builder he received a letter from John W. Kennedy, chief of police of Rushville, from which the following are excerpts:

"The bridge of which I send pictures was built in 1883 by my grandfather, A. M. Kennedy, and my father, E. L. Kennedy. It is built of Michigan white pine and has two 120-ft. spans, with a 16-ft. roadway, a 5-ft. sidewalk on each side and a load clearance of 16 ft. It is one of the 50-odd bridges built in central and southern Indiana by three generations of Kennedys. The last one was built by my father and two brothers in Wayne County, in 1918.

"The oldest of the Kennedy bridges still standing is at Dunlapsville, Ind. It was built in 1870 and is practically as good today as ever. It has two 150-ft. spans. The best and nicest bridge was built at Connersville in 1887. The roadway is 20 ft. and has a 5-ft. sidewalk on

each side. This bridge also has two 150-ft. spans. The longest bridge still standing was built in 1879 across White River 9 miles below Indianapolis; it has three 150-ft. spans. The longest single span was built in 1883 in Greene County; it has a 200-ft. span. E. L. Kennedy is still living and is 81 years old."

The photograph of the Rushville bridge is reproduced here. It is still a sturdy looking structure after 45 years of service and is besides, as readers must agree, a notably handsome example of bridge architecture.

The Decimal Point With the Slide Rule

By William J. Alcott, Jr.
Assistant Professor, Northeastern University, Boston, Mass.

IN SLIDE RULE computations involving complicated formulas or which involve either very large numbers of very small numbers, the position of decimal point is often determined with some difficulty. Such rules as are in use involving the manipulation of the rule, as, for instance, the direction in which the slide protrudes, fail when other scales than the *C* and *D* scales are used.

The use of "one-place" logarithms as explained in this article not only fixes the decimal point but also provides a rough but independent check on the accuracy of the computation. This very convenient method of memorizing one-place mantissas has the double advantage of being easy to carry in the mind and of being correct to two places, though but one is memorized.

The mantissas which are committed to memory are as follows: The mantissa for 2 is 0.3. Then for numbers 3 through 6, the mantissas are two more than the number—that is, for 3, 0.5; for 4, 0.6; for 5, 0.7; and for 6, 0.8. Then for the numbers 7 through 9, the mantissas increase by steps of half-tenths; thus the mantissa for 7 is 0.85; for 8 is 0.90 and for 9 is 0.95.

Numbers falling between 1 and 2 should be given mantissas of 0.1, 0.2 or 0.3 as judgment dictates.

The following table shows the result. The column of mantissas to two places is added for comparison. It will be seen that with the exception of the mantissas for 3 and 6 what is remembered for one place is accurate for two.

Number	Memory Mantissa	Two-Place Mantissa	Number	Memory Mantissa	Two-Place Mantissa
2	0.3	0.30	6	0.8	0.78
3	0.5	0.48	7	0.85	0.85
4	0.60	0.60	8	0.9	0.90
5	0.7	0.70	9	0.95	0.95

White Stripe on Edges of Highway Proves Aid to Traffic

WHITE stripes painted along the edges of the pavement on California highways as an experiment have been highly successful, according to a bulletin of the California Division of Highways. As a preliminary test a 20-ft. asphalt paving with oil-mixed rock borders, which blended closely with the color of the highway, was striped with a 6-in. white line at each edge of the paving and an orange line along the center. The center line, which is becoming common practice throughout this state, was described in *Engineering News-Record*, April 26, 1928, p. 671.

The recent improvement was to add the two side lines, tending to define the traffic lane more clearly and keep traffic off the shoulders. The edge line is of particular advantage when meeting traffic in the fog or at night, as it defines the side of the roadway even against glaring headlights. These added lines in no way lessen the value of the center line, which is considered indispensable, but the combination of the three is said to add materially to the safety, speed and comfort of the traveling public.

The equipment used in marking the highway is a light truck and a striping machine. Cost of this work varies according to the type and conditions of the surface of the highway. A fairly porous surface will require as much as 18 gal. of paint per mile, while a dense surface will use about 13 gal.

SIDE STRIPES HELP CENTER LINE IN GUIDING TRAFFIC

From Job and Office

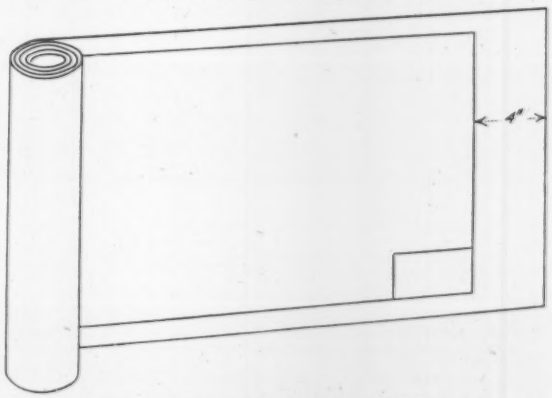
Hints That Cut Cost and Time

Protecting Tracings

By Morton Schwam
Philadelphia, Pa.

A VERY convenient method of filing and protecting the original tracing of a drawing may be accomplished as shown herewith.

The border on the right-hand end of the tracing is made 4 in. wide and rolled up, and a rubber band slipped over it, making a roll 1 in. in diameter, thus saving space for filing. The body of the drawing containing the information is protected against any damage that may be caused by water, ink or fringed edges by the extra wide border which will wrap around the rolled tracing.



DEVICE FOR PROTECTING TRACINGS

From Job and Office

For Contractor and Engineer

The cost of the extra few inches of tracing cloth has very often more than compensated for the damage that may have been done to one tracing.

Drainage Channels Closely Spaced Under Concrete Lining of Reservoir

IN THE construction of the North End reservoir, recently built by the city water department at Tacoma, Wash., the concrete lining was laid in slabs 25 ft. square and drainage channels were put under most of the joints between slabs in sides and bottom, thus providing adequate escape for seepage should the joints leak. This provision is expected to prevent settlement and opening up of joints with resultant water loss. A copper water stop and asphaltic filler were used in joints, as shown in the accompanying drawing.

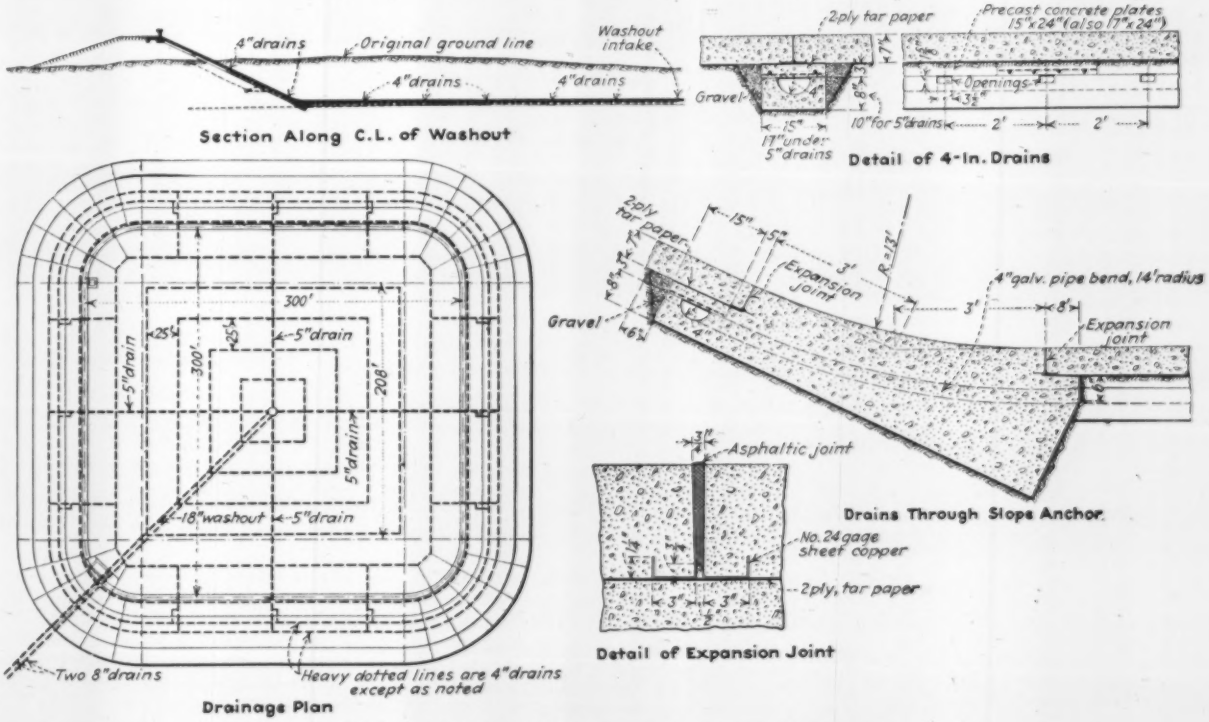
Before the concrete lining was poured a trench was excavated along the line where the drained joints were to be located, and in this trench was cast a concrete rib or footing in the top of which was a semicircular channel. Seepage has access to this channel through grooves on either side spaced on 2-ft. centers. Over this trough was laid a series of 17x24-in. precast reinforced-concrete plates 3 in. thick, these plates being intended as a covering for the channel and as a support for the edges of the lining slabs. The plates over the drain were purposely left without bond to the concrete below to facilitate movement without cracking.

The tops of drainage channel covers were placed flush with the subgrade for the concrete lining, which was then poured in the usual manner with the construction joints lying over plates on the center line of the drainage gallery just described. All drainage galleries discharge into two 8-in. cast-iron collecting pipes at the center of the reservoir, whence the drainage is conveyed under the reservoir embankment to the washout chamber. An 18-in. cast-iron washout pipe also leads from the center of the reservoir to the washout chamber.

Dividing the lining into slabs 25 ft. square and providing these with light reinforcing is expected to prevent shrinkage cracks within the slabs themselves. The lining was finished in December, 1927, and the reservoir was filled promptly after completion.

W. A. Kunigk, superintendent, water division, department of public utilities, Tacoma, Wash., reports that to date only very slight seepage has developed.

PLACING DRAIN AND COVER BEFORE POURING LINING



DETAILS OF DRAINAGE SYSTEM UNDER RESERVOIR

News of the Week

Reorganization of Federal Engineering Departments Urged

Civil Engineers' Board at Dallas Acts on Technical and Professional Matters

Special Staff Dispatch

REORGANIZATION of engineering departments in the federal government and decrease of the tax on earned incomes were called for in resolutions adopted by the board of direction of American Society of Civil Engineers, meeting this week in Dallas, Tex. The reorganization resolution is general in character, but definitely places the society on record as favoring careful study and thorough reorganization. The question of reducing the tax supports a general movement and a specific resolution received from the Los Angeles section. It was referred to the sections to take up with Congressmen.

Co-operation With Engineering Council

Authorization was given to the committee on salaries to co-operate with a committee of Engineering Council on improving the general status of engineering and allied technical professions. The purpose is to collect, analyze and disseminate information to engineers and the public on engineers' earnings, compare these with those of other professions, ascertain professional status, determine trends of the profession, make classifications, particularly in federal service, look into registration problems, determine responsibility as to technical education, and furnish expert guidance in critical relationships such as recently arose between engineers and the municipalities of New York and Chicago.

Fourteen representations on Engineering Council assembly were authorized. Six professional conduct cases were considered. Student chapter charters were granted at Clarkson College of Technology and Tufts College, bringing the total to 98 and student members to 5,500.

Request for participation in redrafting the New York building code was referred to the local section. For the purpose of effecting a more intimate relation among members in the several sections of the country relative to their specific technical problems, the board of direction set up territorial committees advisory to the committee on meetings, consisting of the vice-president and directors in each zone. The zone committee is to collaborate with members through section meetings and otherwise as to desirable meeting places and programs to be featured.

Maine to Vote on Export of Power in September

The legislature of the State of Maine before it closed its recent session approved a proposal to submit to a referendum vote in September a modification of the law which now prohibits the exportation of excess water power from the state. The proposal to be voted on permits the exportation of such power subject to a 4 per cent excise tax on the gross revenue from its sale.

Raymond S. Patten Director of Coast and Geodetic Survey

Raymond S. Patten was appointed director of the Coast and Geodetic Survey by the President on April 22 to replace E. Lester Jones, who died on April 9. Mr. Patten is a hydrographic and geodetic engineer, a 1904 Ph.B. graduate of Western Reserve University. He takes office at the age of 46 with 25 years of service, having come up through the ranks of the organization. Mr. Patten saw field duty in Alaska, the Philippines and along the coast of the United States until 1917, when he served with the Navy Department during the World War. Since that time he has been chief of the division of charts, Coast and Geodetic Survey. The new director is chairman of the shore line committee, National Research Council, director of the Shore and Beach Preservation Association and a member of the U. S. Geographic Council and the American Society of Civil Engineers.

Multiple Dwelling Law for New York City Approved

The multiple dwelling law for cities of more than 800,000 population, passed by the New York State Legislature, has been signed by the Governor. It replaces the tenement house law now on the statute books and very much out of date as regards modern apartment houses.

The new law met much opposition on account of its building height provisions. It provides that such height shall not be more than 1½ times the width of the street up to a street width of 100 ft., above which point 3 ft. may be added for each 1 ft. setback up to 1½ times the street width. Towers to a height of three times the street width, set back as above, may be built where the lot area exceeds 30,000 sq.ft., the tower to occupy not more than 20 per cent of the area and to be 70 ft. from the nearest lot line at its top.

No multiple dwelling over 75 ft. or six stories in height may hereafter be built of non-fireproof construction.

Hearing on Chicago Diversion Continued Before Special Master

Four Years Required to Complete Disposal Plants—Storm-water Problems

FURTHER testimony as to a reasonable length of time for the Sanitary District of Chicago to complete its sewage-treatment works and to cease lake diversion was presented by witnesses for the Great Lakes States on April 16 to 23 at the hearings in Washington before Special Master Charles E. Hughes. According to H. C. Linnell, engineer and vice-president of the Foundation Company, the proposed Southwest Side disposal plant will be the controlling factor, taking longest to complete. He estimates that it can be finished in four years after award of contract. W. J. Hunkin, a Cleveland contractor, arrives at a figure of 1,500 calendar days, a difference of only 3 per cent. Both witnesses declared that they would be willing under contract to guarantee completion within four years.

Sanitary Engineers Recalled

The four sanitary engineers who appeared on April 15 were recalled by the defense to explain the basis of their estimates. It was admitted that they had met in Chicago only on the Friday preceding and thus had but three days to arrive at their final conclusions, part of which were reached on the train to Washington. Few of the major points brought out in the direct questioning were in effect retracted.

Col. Curtis M. Townsend, retired, former president of the Mississippi River Commission, was called to express his opinion regarding the effect on navigation in the Chicago River with diversion cut off. He does not think that diversion is necessary to shipping but rather retards it because of the current. He agreed with H. C. Inches, steamer captain, who appeared April 15, in the belief that sewage pollution does not affect navigation.

Storm-Sewage Disposal

Storm-sewage disposal became a main issue as Prof. H. W. King came up for cross-questioning. Under present conditions any sudden rain or thaw merges with the sustained flow of 8,500 sec.-ft. and passes down the Drainage Canal without frequent danger of current reversal, which would send polluted water to the city's intakes. If, however, all diversion is shut off, the question arises whether

control works can be constructed to start from zero flow and send a concentrated storm runoff peak down the canal before a reversal occurs.

Professor King answered in the affirmative from a theoretical study which is believed to be among the first of its kind. It was admitted that some of the basic data were sketchy in spots and that no provision had been made for a lock at the proposed Western Ave. control gates.

Before adjournment on April 18 an agreement was reached to complete the taking of testimony and rebuttal before Mr. Hughes sails for Europe on May 1. Thus full use can be made of the master's time and the final briefs prepared during the summer. It is expected that the Supreme Court will be able to hand down a decision in October governing the progressive cessation of flow.

Chicago May Not Intervene

The Supreme Court on April 22 denied the petition of the city of Chicago to intervene as defendant in the hearings before the special master on the lake diversion case. In a brief submitted by counsel for the city requesting permission to intervene, it is stated that a new water-supply system costing $123,000,000 will have to be built if sewage is discharged into the lake, "even if such sewage is artificially treated to the greatest practicable extent known to the art."

In addition it will be necessary to change the sewerage system into two separate units, one for the drainage and one for the sewage, it is brought out in the brief. The cost of this change of the sewerage system is estimated to be $330,000,000. The city is without means to finance any such extensive construction program for its waterworks and sewerage system, it is protested. As to the amount that will be required to construct sewage-purification works, the brief estimates that this will cost "upward of $176,000,000."

Moreover, it is brought out that the discharge of artificially treated sewage and stormwater into the lake will damage utility companies in the city to the extent of $186,000,000 by depriving them of condensing water for the various plants located on the Chicago River. This loss will be reflected in higher utility rates, it is charged.

Lake Diversion Necessary

"Control works are not necessary in the interests of navigation," testified Major Gen. Edgar Jadwin, Chief of Engineers, in the Chicago diversion case hearing of April 23. "Their purpose," he continued, "is to prevent the discharge of polluted water from Chicago River into Lake Michigan, where it would menace the city water supply and beaches. The present Lockport control may be found satisfactory with a total diversion as low as 5,000 sec.-ft. annual average or possibly less.

"The practical solution, in my opinion, is systematically to reduce the contamination and the total diversion, observing the results obtained by the best operation on the present control at Lockport and the accumulating data on the behavior of the flow with this progressively decreasing diversion. This procedure will demonstrate in ample time whether any control works are necessary (for sanitary purposes) and will furnish a correct basis for their design."

The Corps of Engineers, it was emphasized, does not retract its previous contention that 5,000 sec.-ft. will be necessary to maintain navigation on the Illinois River under the plan of improvement now under way. However, General Jadwin testified as to the hypothetical effect of control works if there is no diversion except for stormwater and also on the basis of different quantities between 1,000 and 7,000 sec.-ft. He considered alternative locations near the head of the canal and near the mouth of the river, commenting on the advantages and disadvantages of these options. This testimony was prepared under request of the special master.

Defense rebuttal began with the appearance of J. C. Reuttinger, general manager of John Griffith & Sons, contractors who built most of the West Side sewage-treatment plant in Chicago. As adjournment was taken, defense counsel was gathering evidence to show that the state's witnesses had not allowed sufficient time for completion of the Sanitary District's construction program.

PROPOSED SECOND NORTH-SOUTH RAILWAY ON PACIFIC COAST

Location of proposed railway to connect the Great Northern and Western Pacific. The distance from Klamath Falls to Keddie is about 200 miles. (See editorial comment on p. 659 of this issue.)

New England Sewage Works Association Launched at Hartford

Constitution Adopted, Officers Elected and Half-Dozen Papers Read at All-Day Meeting

FORTY sewage-works operators and chemists, consulting engineers and representatives of state health departments joined in forming the New England Sewage Works Association at a meeting held at Hartford, Conn., April 23, in conjunction with the New England Health Institute. At the same time a half-dozen papers on sewage treatment were read.

Officers Elected

Officers elected for the first year were: president, Stuart E. Coburn, chief chemist, Metcalf & Eddy, Boston; vice-presidents, Julius W. Bugbee, chemist and superintendent sewage-works, Providence, and Warren J. Scott, engineer Connecticut State Board of Health; secretary, F. W. Gilcreas, of Weston & Sampson, Boston; treasurer, Roscoe H. Suttie, associate professor of civil engineering, Yale University, New Haven. The chairman of the organization meeting was Edward Wright, assistant engineer, Massachusetts Department of Health.

Papers Read

"The Newer Knowledge of Sludge Digestion," by Prof. Gordon M. Fair, Harvard University, was the first paper read. It dealt chiefly with research work, particularly as regards heat as an aid to digestion—temperatures sufficient to promote activity of thermophilic bacteria. In practice, the heat may be obtained from the gases produced by sludge digestion. The combination of heat with the use of lime to regulate the acidity of the sludge makes separate sludge digestion an easier process than digestion in Imhoff tanks, said Professor Fair.

In a summary of elements of design and operation of sewage tanks, C. A. Emerson, Jr., head of the Philadelphia office of Fuller & McClintock and formerly engineer of the Pennsylvania Health Department, said that closer spacing for bar screens in advance of Imhoff tanks is now being practiced, down to ¼ in. Low velocities in grit chambers matter less now that means of washing the grit to free it of organic matter are available. As to utilizing gas from digestion tanks, except for works purposes, Mr. Emerson said that conditions here are different from those abroad, where the sludge gas can be turned over to municipally owned gas works, of which there are very few in America. Moreover, where natural gas sells for 15 to 20c. per 1,000 ft. the market for sludge gas is poor.

"Difficulties With Sewage-Works Operation," was the title of a paper by John R. Downes, superintendent of the

Plainfield (N. J.) joint sewage-works. The sewage-works manager, said Mr. Downes, is a production manager without an outlet for his product. Instead of tank baffles, which create dead spaces, Mr. Downes suggested the use of targets to intercept eddies, as practiced by P. M. Daniels at Trenton, N. J. Wonderful strides have been made in sludge digestion, Mr. Downes said, but little in handling the ripened sludge. For this a quick mechanical means of sludge drying is needed.

A concise and interesting outline of the activated sludge process was presented by William R. Copeland, sanitary engineer, State Water Commission, Hartford, Conn., formerly chief chemist, Milwaukee Sewerage Commission. Values of sewage-works records were set forth by J. Frederick Jackson, consulting engineer, New Haven, formerly engineer, Connecticut Board of Health. Among these values is their use in case of litigation. In conclusion, Mr. Jackson suggested this slogan: "Educated city officials, trained operators, simplified reports."

The final paper, by Roy S. Lanphear, chemist in charge of the sewage-works of Worcester, detailed the operating methods of the sprinkling filters of that city, which are successfully handling Imhoff tank effluent resulting from sewage high in trade wastes. The cost of filter operation in 1928 was 85c. per million gallons.

Birmingham Seeking Protection Against Floods

Measures to protect Birmingham, Ala., from frequent floods when Village and Valley creeks overflow, inundating a large area of the city, are in contemplation and it is probable that the voters will be asked to approve a bond issue early next year for this purpose. Surveys in progress since 1926 will have to be completed before an accurate estimate of the cost can be made, but about $10,000,000 will be necessary.

Tidal Power Scheme Bill Failed to Pass Canadian Legislature

The bill which granted an extension of two years to the time in which the Dexter P. Cooper Company must start construction of its power project on Passamaquoddy Bay between the Province of New Brunswick and the State of Maine was defeated in the private bills committee of the Canadian House of Commons on April 16.

Dotsero Cutoff Authorized

Permission to build the Dotsero cutoff to connect the Denver & Rio Grande Western Railroad with the Denver & Salt Lake Railway has been granted to the latter road by the Interstate Commerce Commission provided the D.&R.G.W. is permitted to operate over the D.&S.L. through the Moffat tunnel into Denver.

Wide World Photo

WRECKAGE IN THOMAS ST., NEW YORK, AFTER TWENTY-STORY PLUNGE OF 3½ TONS OF STEEL BEAMS

Four Killed as Steel Derrick Drops Beams 20 Stories

Dropped by a steel erection derrick from the twentieth floor level of the Western Union Building in New York, a bundle of floorbeams last Saturday crashed through a loaded bricklayers' scaffold and into the street, killing four workmen and injuring a dozen more.

Two of those killed were hurled from the scaffold at the eighth floor; the other two were caught beneath the wreckage of the wooden sidewalk canopy.

The accident took place as the electric-drive derrick was hoisting a load of beams weighing approximately 3½ tons from the Thomas St. side to the top of the nearly completed 24-story steel framework. The derrick, located on the twentieth floor, had completed hoisting its load and was starting to boom up when something failed and the beams crashed to the ground.

As yet it has not been exactly determined just what happened or what was the cause. According to a statement made to the district attorney's office by the hoisting engineer, a fuse blew out, shutting off the power and dropping the load. The automatic brakes failed to hold and the operator was unable to check the fall with the foot brakes, according to his statement. Rated as a standard 10-ton rig, the derrick was loaded to a small part of its capacity. The contractor and hoist manufacturer are co-operating in determining the cause of the failure and the possibilities of preventing similar future accidents.

No pedestrians were injured in the crash, although both sidewalks and the narrow street are open to traffic. Nearly 14,000 tons of steel had been erected in the building without a serious accident. Post & McCord, New York, are erecting the steel. Marc Eidlitz & Son, Inc., New York, is general contractor.

Boulder Dam Preliminary Studies in Active Progress

Studies preliminary to the construction of Boulder dam are in active progress, it is stated by R. F. Walter, chief engineer of the U. S. Bureau of Reclamation. Supplementary surveys are being made in the canyon relative to the disposal of excavated material about the dam and tunnel. To dump this spoil into the river, it is pointed out, would obstruct the channel and raise the level at the cofferdams. The deepness and narrowness of the canyon make disposal difficult. A survey of the railroad to the dam site is finished, hence work on the line can begin as soon as authorization is received.

Studies are being made in Mr. Walter's Denver office toward providing electric power for construction. It is possible to bring transmission lines 500 miles from plants in southern California. Otherwise it will be necessary to construct a steam plant on the job, probably near the dam.

As soon as reorganization is effected in the engineering forces, Mr. Walter expects to start work on designing the dam structure in order that the preliminaries will be out of the way when construction appropriations become available. Most of this work is being done by the bureau's personnel under the regular allotment pending compact agreements between the states concerning the sale of power and division of waters.

Permission Refused for Bridge Over James River

The Richmond-Hopewell Bridge Company will not receive permission to construct a highway cantilever bridge across the James River in the vicinity of Dutch Gap, the Chief of Engineers has ruled, on the ground that the channel would be restricted seriously.

WASHINGTON NOTES

By Paul Wooton
Washington Correspondent

U. S. Department of Labor Seeks Legislation to Safeguard Workers Employed on Federal Buildings

HAVING accumulated statistics which show an increasing rate of demolition accidents in the building industry, the U. S. Department of Labor is seeking to secure legislation that will safeguard the worker on federal projects. The statistical bureau of the Labor Department reports that most of the state building codes are out of date, especially with reference to demolition work. It has been found that 24 states now have laws for the protection of employees on buildings, nineteen have laws giving commissions power to make regulations on the subject and ten have both types of laws.

Officials of the Labor Department are proposing a council of state regulatory bodies for the purpose of revising and standardizing building codes. It is believed that the calling of such a conference is becoming imperative as building contractors increase their participation in interstate business. It is argued also that since it is possible for the government to require the railroads to use safety couplings on freight cars, it ought to be possible to secure an act of Congress covering the construction of federal buildings.

The Associated General Contractors, however, while expressing itself as desirous of doing anything to promote safety in construction work, is opposed to the passage of legislation for this purpose. The organization believes that better results can be secured by an educational campaign within the industry itself, stressing the economic losses of accidents. Enactment of additional legislation on the subject, it is pointed out, would result mainly in giving surety companies technical excuses to escape their responsibilities. It is held also that it is difficult to draw up any arbitrary set of laws for an industry such as the building trades, which must change its entire setup on every new job.

Guide Levees 300 Ft. Wide at Base for Bonnet Carré Spillway

Guide levees 300 ft. wide at the base have been prescribed by the army engineers for the Bonnet Carré spillway. This is 100 ft. wider than the standard levee on the main river. The guide levee will be 17 ft. high, which is 3 ft. lower than the levees along the river. This height allows a margin of 3 ft. above the maximum crest that can be diverted through the spillway. As the flood-control act provides for the control of the discharge through the spillway when diversion is necessary, experiments now are in progress to determine just how much of the needle dam at the intake will have to be removed to prevent a stage in excess of 20 ft. on the Carrolton gage. With the spillway discharging at the rate of 250,000 sec.-ft., there never has been a time since records were taken that enough water has come down to make for a stage higher than 20 ft. Bids for the construction of the levees will be opened May 15.

Bids were invited on March 22 for the construction of the 35 miles of setback levee at New Madrid. This levee, which will form the inner embankment of a riverbank floodway, will be 20 ft. high and 200 ft. wide across the base. The cost of construction is estimated at $5,000,000.

Survey for All-American Canal to Be Undertaken

Negotiations are nearly completed between the Bureau of Reclamation and the Imperial and Coachella Valley Irrigation Districts for a survey to determine the final location of the All-American Canal. A form of contract has been executed and its approval is expected within the next few days. The survey will show whether it is cheaper to divert the canal flow at the existing Laguna dam or to construct a new dam 4 miles upstream. The latter plan could raise the canal level about 20 ft., reducing the heavy cut along the international boundary. A minor advantage would be the additional head available for irrigation, which might throw a few hundred additional acres into cultivation.

Opposing factors are the cost of the new dam, which would be higher than the Laguna and probably at a less favorable site. The topography is not expected to permit placing such a dam more than 4 miles upstream from the existing structure. The additional canal length would also add to the project cost. Survey expenses will be borne by the districts. The completed study is expected to serve as a basis for future construction under the Boulder Canyon act, by the provisions of which funds are not yet available. This work will be under the direction of R. F. Walter, chief engineer of the Reclamation Bureau, with offices in Denver.

Wolf Resigns as Chief Engineer of Maryland P.S.C.

H. Carl Wolf, chief engineer of the Maryland Public Service Commission since 1922, has resigned, effective June 1, to become assistant to the operating vice-president in charge of gas operations of the Central Public Service Company, with headquarters in Chicago.

Mr. Wolf first served as assistant engineer of the Illinois Commerce Commission and later managed the Edwardsville Water Company, of Edwardsville, Ill. After the war he became connected with the staff of Griffenhagen & Associates. In 1920 he made a study of the organization and personnel conditions in Maryland.

He is president of the Baltimore Engineers Club and a director of the Baltimore Section of the American Institute of Electrical Engineers.

Secretary Good Named Chairman of Federal Power Commission

President Hoover has designated James W. Good, the Secretary of War, to be chairman of the Federal Power Commission. Under the water-power act the President must designate one of the three Secretaries comprising the commission as its chairman. In view of the fact that Secretary Wilbur, of the Interior Department, had had extended contact with the water-power situation, there had been some suggestion that the chairmanship of the new commission might go to him.

Secretary Lamont Heads Conference on Highway Safety

Secretary of Commerce Robert P. Lamont has accepted the chairmanship of the National Conference on Street and Highway Safety, the organization formed by ten national associations to promote uniform traffic regulations and other measures looking toward improving traffic conditions and reducing street and highway hazards.

The conference was created in 1924 under the chairmanship of Herbert Hoover, then Secretary of Commerce, who continued to serve as head of the organization until his election to the Presidency.

Engineering Societies

CALENDAR

Annual Meetings

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York; spring meeting, Dallas, Tex., April 24-26.

AMERICAN WELDING SOCIETY, New York; annual meeting, New York City, April 24-26.

AMERICAN ROAD BUILDERS' ASSOCIATION, Washington, D. C.; annual meeting, Washington, May 2 and 3.

NATIONAL FIRE PROTECTION ASSOCIATION, Boston; annual convention, Memphis, Tenn., May 13-16.

AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia, Pa.; annual meeting, Atlantic City, N. J., June 24-28.

AMERICAN WATER WORKS ASSOCIATION, New York; annual meeting, Toronto, Canada, June 24-28.

AMERICAN ASSOCIATION OF ENGINEERS, Chicago; annual meeting, Mexico City, Aug. 26-28.

* * *

The Fourth Conference of Secretaries of Engineering and Allied Technical Organizations will be held on June 6 and 7 in the rooms of the Western Society of Engineers, Chicago, Ill.

The Smoke Prevention Association will hold its 23d annual convention at Kansas City, Mo., May 14 to 17. The secretary is Frank A. Chambers, chief smoke inspector, Chicago.

The Arizona Public Health Association will hold its second annual meeting in Prescott April 16 and 17. The program committee is arranging for

general meetings of interest to all sanitarians and special sessions for health officers, water and sewage plant operators, and dairy inspectors.

THE TENTH ANNUAL CONVENTION of the National Council of State Boards of Engineering Examiners will be held in Yellowstone Park, Aug. 25-28. Engineers and surveyors, with their families, are invited. The program includes a tour of the park. The secretary of the council is T. Keith Legare, P. O. Box 264, Columbia, S. C.

THE PROFESSIONAL ENGINEERS OF OREGON, a group of engineers organized early this year, held their first annual meeting at the University Club in Portland, April 10. The association now numbers more than 200 members. Officers chosen at the organization meeting were re-elected at the annual session. They are J. C. Stevens, president; Walter Haynes, vice-president, and Fred D. Weber, treasurer.

THE INTERNATIONAL GROUP of the American Road Builders' Association is being organized for the purpose of extending the activities of the Pan-American Division and furthering the interests of road programs in the South American countries. To this end it is proposed to distribute among these countries good roads publicity, including specifications of standard methods, accepted materials and approved equipment, as well as moving picture films appropriate for this purpose.

THE LOS ANGELES SECTION, American Society of Civil Engineers, held its regular monthly meeting on April 10 at the Engineers' Club. E. C. Eaton, chief engineer, Los Angeles County Flood Control District, was the principal speaker. Mr. Eaton discussed the general plan of flood control in Los Angeles County and, more particularly, gave a description of the plans and methods of procedure for the San Gabriel dam, now under construction.

THE SAN FRANCISCO SECTION of the American Society of Civil Engineers at its regular bi-monthly meeting at the Engineers' Club on April 16 heard Charles Gilman Hyde, professor of sanitary engineering, University of California, on "Some Observations and Impressions of Sanitary Engineering Works in Europe." Professor Hyde's address was illustrated by numerous lantern slides obtained during his recent visit to Europe.

MONTCLAIR SOCIETY OF ENGINEERS—Speakers before the Montclair (N. J.) Society of Engineers on April 19 were Charles Whiting Baker, for many years editor of *Engineering News*, and H. S. Simpson, traffic engineer of Essex County. Mr. Baker discussed mosquito and flood control in the Passaic Valley and the future water supply of northeastern New Jersey, particularly the Passaic flood-control and meadow drainage project reported on last year by C. C. Vermeule (see *Engineering News-Record*, Dec. 20, 1928, p. 931).

Personal Notes

W. C. CURD has resigned as vice-president and chief engineer of the Biggs Construction Company, of Akron, Ohio, and has moved to Detroit.

Major DONALD H. CONNOLLY, now in charge of the First District on the Mississippi River, has been ordered to Fort Leavenworth, Kan. Major Connolly will leave his present work about Aug. 1.

HAYWOOD R. FAISON has been appointed chief engineer on the R. W. Hebard & Company contract for building the trans-Andean "Highway to the Sea," to succeed JOHN H. CATON, 3D, resigned.

B. R. TYLER, formerly in the industrial engineering department of the Decatur Iron & Steel Company, has accepted a position as structural steel salesman and designer with the Arkansas Foundry Company, Little Rock.

JOHN I. STOCKWELL, of Boston, recently construction engineer for the C. A. D. Bailey Company, of Atlanta, Ga., has become associated with the John W. Doty Corporation, New York City, in engineering work connected with foundation projects. Previously Mr. Stockwell was connected with Stone & Webster as structural engineer.

BERNARD L. CROZIER, formerly chief engineer of Baltimore, has been appointed chief engineer of the Metropolitan District of Baltimore County. He fills a vacancy caused by the resignation of A. E. WALDEN, who left the post because of ill health. Recently Mr. Crozier has been serving as a consulting engineer for Baltimore and has been relieved of this duty at his own request.

KENNETH C. ROBERTS, for the last 3½ years with the Strauss Engineering Corporation on design and supervision of construction, is now in the design office of the Hamilton Bridge Company, Hamilton, Ont. Mr. Roberts was previously connected with the American Bridge Company and the Dwight P. Robinson Company, Inc., on bridge and building work.

FREDERICK AURYANSEN, who has been bridge engineer of the Long Island Railroad, with headquarters at Jamaica, N. Y., since 1907, has been made assistant engineer of bridges and buildings of the New York zone, with headquarters at Pennsylvania station, New York City. This change is the result of the consolidation of the Long Island Railroad as part of the New York zone of the Pennsylvania Railroad.

A. J. GILARDI has opened an office as civil and consulting engineer in Seattle, Wash., and will specialize in hydraulic and structural engineering, reports, investigations and experiments. Mr. Gilardi was graduated from the Zurich Polytechnic in Switzerland and received a master of science degree from the Massachusetts Institute of Technology. He has served with the Fargo Engineering Company, Jackson, Mich., the J. G. White Engineering Corporation, New York City, and Mead & Scheidenhelm, New York City.

Obituary

GEORGE H. BODETTE, junior member of the firm of Edward Bodette & Sons, of Toledo, Ohio, died on March 14 following an operation for appendicitis. Mr. Bodette was 26 years old.

PETER S. HANSEN, of Portland, Ore., died in that city on April 12, at the age of 80. Mr. Hansen was born in Norway and came to the United States in 1882. For fourteen years he was division engineer for the Southern Pacific Railway and he was also locating and construction engineer for several railroads on the Pacific Coast.

FRANK W. SMITH, 86 years old, a civil engineer, died on April 19 at Santa Barbara, Calif. He was formerly a resident of Frederick, Md. Mr. Smith was at one time a civil engineer with the Pennsylvania Railroad at Pittsburgh and then became associated with the elevated line in New York. Later he went to New Mexico, where he served as chief engineer in charge of the construction of the railroad from Albuquerque to The Needles.

WOLFE H. OLTARSH, a pioneer in the use of steel for building construction, died at his residence in New York City on March 24. Mr. Oltarsh came to New York from Russia at the age of 16. He first worked for R. Hoe & Company, and afterward went into business for himself. At a time when iron and steel were scarcely used at all in building construction, he perceived their possibilities and put his theories into practice through his own firm, the Oltarsh Engineering Company.

WILLIAM JOSEPH DUNCAN, subway construction engineer, died in New York City on April 16. He was 60 years old. Mr. Duncan, shortly after his graduation from the Worcester Polytechnic Institute, became assistant engineer of the Flint & Pere Marquette Railroad, after which he took charge of the engineer's office for the Louisville & Nashville Railroad. In 1891 he was appointed a designer and cost estimator for the Detroit Bridge & Iron Works. Later he became assistant bridge engineer for the Michigan Central Railroad, in Detroit, and in 1900 went with Milliken Brothers, engineers and contractors, in New York. From this time until 1907 he took charge of the planning and designing of underground and elevated railways for the Rapid Transit Commission. For the last twenty years Mr. Duncan had been employed by the Public Service Commission, the Transit Construction Commission and the Board of Transportation. He was a member of the Municipal Engineers of the City of New York and the American Association of Engineers.

Construction Equipment and Materials

Welding School Expands

To meet a rapidly increasing demand for practical instruction in arc welding, the welding school maintained by the Lincoln Electric Company, Cleveland, Ohio, is greatly expanding its facilities. It is said that the present expansion has been necessary to meet the needs of manufacturers who require skilled arc welders. No tuition is charged at the school and any ambitious mechanic is free to take the course up to the capacity of the school. The course is of six weeks' duration and students are required to conform to ordinary shop rules and to keep conventional shop hours. Individual rather than class instruction is the rule. The Lincoln Welding School is under the supervision of Arthur E. Madson.

Business Notes

PIONEER GRAVEL EQUIPMENT MANUFACTURING COMPANY, Minneapolis, Minn., has been formed to take over the line of gravel- and rock-crushing equipment manufactured and sold by the Russell Grader Manufacturing Company, following the merger of the Russell company with the Caterpillar Tractor Company. Since the merged company will devote its efforts toward the manufacture of tractors and tractor-drawn machinery, a number of the former employees and officials of the Russell company have formed this new company, which will devote its efforts exclusively to the manufacture and distribution of gravel equipment, consisting of eleven sizes of portable crushing, screening and loading plants, and several sizes of draglines, storage bins, conveyors, dragline buckets, shaker and revolving screens.

BREWSTER-BADEAU & COMPANY, INC., 76 William St., New York City, announces the establishment of a separate toll bridge insurance department to handle the various kinds of insurance carried by its clients owning toll bridges.

MANITOWOC ENGINEERING WORKS, Manitowoc, Wis., announces that the Condon Bearing & Supply Company, Pittsburgh, Pa., has been appointed its representative in western Pennsylvania and West Virginia for the sale of cranes, shovels, draglines and buckets.

MICHIGAN VALVE & FOUNDRY COMPANY, Detroit, announces the inauguration of a new service whereby technical advice is made available to those in charge of projects involving water supply and distribution, drainage and sewage work, particularly where piping is an important factor. The administration of this service has been turned over to Eldon S. Clark. Mr. Clark, a graduate of the Massachusetts Institute of Technology, has served with Barrows & Breed on the construction of hydraulic and railroad projects. Later he became allied with Stone & Webster as designer and assistant engineer on power-plant work and industrial building construction. For eight years Mr. Clark served with Metcalf & Eddy as assistant engineer engaged chiefly in water-supply and sewage-disposal work.

BAY CITY SHOVELS, INC., formerly Bay City Dredge Works, Bay City, Mich., announces the letting of a contract for the construction of a new factory building of brick and steel to provide an additional 18,000 sq.ft. of floor space necessary for its increased production activities. The structure is to be used as an assembly building and will be equipped with a 10-ton electric traveling crane.

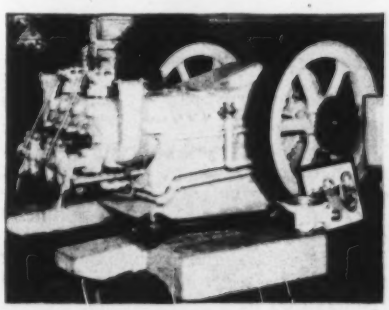
MODERN EQUIPMENT COMPANY, Muskegon, Mich., has been formed to take over the assets of the O. E. Szekely Corporation, of Holland, Mich. Lorimer Dunlevy, formerly general sales manager of the O. E. Szekely Corporation, is head of the new organization. The new company will continue the manufacture of a complete line of direct-connected a.c. and d.c. generating sets, ranging from 3 to 50 kw., and in addition will continue to supply the centrifugal, diaphragm and piston type pumps of the former company.

New Developments

New Diesel Engine Features Low-Pressure Fuel Injection

A new line of diesel engines unique in several particulars has been announced by the Page Engineering Company, 844 Rush St., Chicago. The company states that the engines were originally developed for the sole purpose of driving its excavators but that a demand has arisen for their use in other equipment.

One of the features of the engine is that fuel is injected at low pressure and the compressing and self-ignition of this fuel is controlled by a special apparatus. Adjustment of fuel is made at one place only and all the parts are large and accessible with ordinary tools. The engine is of the horizontal type, in which the Page Engineering Company claims that vibration has been reduced to a point where it is practically negligible. Another advantage of the horizontal engine, according to the company, is that accessibility is greatly increased and all parts can be observed and inspected without dismantling any large pieces.



The small engine shown in the illustration develops between 80 and 105 hp. It has a bore of 10½ in., a stroke of 15 in., and is of the two-cylinder four-cycle type, running at 340 r.p.m. and weighing 13,000 lb. The larger size develops between 120 and 160 hp. It has a bore of 13 in. and a stroke of 20 in. It also is of the two-cylinder four-cycle type and runs at 250 r.p.m. It weighs 28,000 lb.

Fuel consumption for dragline duty is claimed to run about 40 gal. per ten-hour shift on the smaller engine and 55 gal. on the large size. Fuel oil of 28 to 30 deg. Bé. will prove satisfactory. Lubrication is pressure and force feed as the conditions demand. Starting is accomplished by means of compressed air at pressures from 90 to 125 lb. per sq.in. The engines are close coupled to the drum sets, which is said to result in a very compact though accessible machinery deck.

Pipe of Asbestos and Cement Has Many Possibilities

A seamless pipe made of asbestos and cement known as Transite pipe is to be manufactured and sold in the United States and Canada by the Johns-Manville Corporation, New York City, under patents of the Eternit Pietra Artificial, Societe Anonima, of Genoa, Italy. While entirely new to America, the pipe has been in use for a number of years in Europe, where its durability under various conditions of soil and for a great variety of purposes is said to have been thoroughly established. It will be manufactured in the United States in five general classes, one class of light weight designed for flue piping and exhaust stacks and four pressure classes to carry liquids at working pressures of from 40 to 225 lb. per sq.in. The flue pipe is said not to be affected by ordinary stack temperatures, and the pressure pipe is suitable for delivery of hot or cold water, brine and various process liquids and solutions under pressure.

It is said that the principal American markets include the building material field and a great variety of industries such as petroleum, chemical, metallurgical and mining. Railroads and public utilities also constitute large markets.

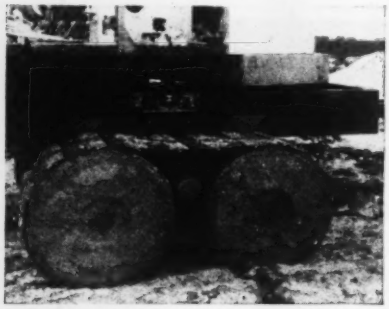
The pipe material is of dense close grain which is readily cut, tapped or threaded with the same tools and in the same manner as is iron pipe. Its weight is from 50 to 65 per cent less than cast-iron or steel pipe and it is claimed to

have a 14 per cent greater delivery capacity. Also it is pointed out that its composition of non-metallic materials guarantees that it will retain its capacity throughout its life, since tuberculation does not occur.

Machinery for manufacturing the pipe is now being built in Italy, and two complete units with a capacity of 2,000,000 ft. of pipe per year will be installed at the Waukegan, Ill., plant of the Johns-Manville Corporation. The pipe will be made in various sizes from 2 to 40 in. in diameter.

New Eight-Wheel Drive Unit With Crawlers for Motor Truck

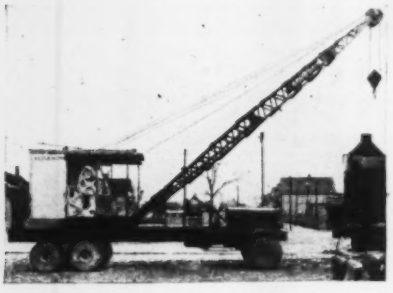
A new drive consisting of eight wheels mounted in a compact, sturdy unit suitable for installation on any motor truck to replace the two ordinary rear wheels of the truck is announced by the Browning Crane Company, Cleveland, Ohio. It is known as the Browning-Christie eight-wheel drive and is said to be powerful enough to pull a truck through axle-deep mud,



snow, sand or ruts that would mire an ordinary truck.

A feature of the drive unit is that its design and method of mounting permits equalization of the load on all eight wheels so that rough ground, railroad tracks, logs, etc., offer no obstacle to its easy operation.

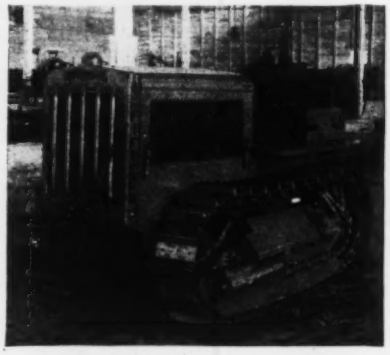
Another striking feature of the eight-wheel drive is that the wheels are



arranged in a tandem of pairs to each side so placed and spaced that they will accommodate a crawler tread. These treads are standard equipment with the drive and are so designed and built that they can be attached or removed in similar manner and time to tire chains. The unit is generally equipped with solid tires, but pneumatic tires can be used if desired.

A New 15-Hp. Tractor

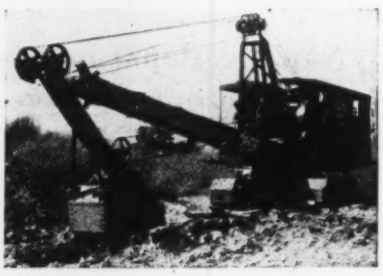
A new model crawler-type tractor known as the "Caterpillar Fifteen" has been announced by the Caterpillar Tractor Company, San Leandro, Calif. From an engineering standpoint, the



company states, the Fifteen is a duplicate of the Ten, which has just gone into production at the company's new Peoria factory. The company now has available in the small tractor range three models, 10, 15 and 20 hp., respectively.

New Diesel Drag Shovel

The new 1-yd. diesel-driven drag shovel announced by the Bucyrus-Erie Company, South Milwaukee, Wis., and convertible for use as shovel, dragline, crane or clamshell, features rugged simplicity as its outstanding characteristic. The boom is of latticed channel construction, while the dipper handle is a steel casting of I-beam section. The dipper, built with an extra-heavy arch



to take the thrust of boom and dipper handle, is designed with long, chisel-shaped reversible teeth held in wedge-shaped sockets without bolts or rivets. The dipper is made with a marked flare to make it easier for the operator to cut a smooth wall and to reduce the time required for dumping. Both hinged-bottom and solid dippers are available in sizes suited to several widths of trench. With a standard 24-ft. boom and 8½-ft. dipper handles, the machine has a maximum digging depth of 21 ft. and a digging radius of 36½ ft. The clear dumping height for a front opening dipper is 10 ft. 3 in. The minimum dumping reach of the same dipper is 19½ ft., while the solid-type dipper dumps between a radius of 17 ft. and a radius of 30 ft.

Ease in Reading Meters

A new long-handled meter box key has recently been developed by the H. W. Clark Company, Mattoon, Ill. The meter box shown in the illustration is the company's new No. 16 Round Southland, which has been on the market about ten months. It is 16 in. in diameter and 16 in. deep, with a full 12 in. lid opening. The meter reader inserts the end of the long handle

key in the hole in the lid of the meter box. A twist of the wrist unlocks the box, after which the lid is lifted to the side. The key is also provided with a lug on the side which may be used to flip the lid back into position.

Construction, Labor and Material

E. N.-R. Index Numbers

Cost			Volume		
Apr. 1,	**1929**	**203.40**	**March,**	**1929**	**382**
Mar. 1,	1929	207.78	February,	1929	378
Apr. 1,	1928	206.40	March,	1928	318
Average,	1928	206.78	Average,	1928	287
Average,	1927	206.24	Average,	1927	263
1913.....		100.00	1913.....		100

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of April 25, with some comparisons, total as follows:

(In Thousands of Dollars)

	Apr. 25, 1929	Apr. 18, 1929	Apr. 26, 1928
Building:			
Industrial.....	$5,800	$10,185	$5,776
Commercial.....	47,123	33,521	33,880
Streets and roads ..	19,788	12,453	18,970
Other eng. constr...	8,570	19,237	13,740
Total.....	$81,281	$75,396	$72,366
Total, all classes, Jan. 1 to Apr. 25:			
1929.....			$1,451,262
1928.....			1,094,521